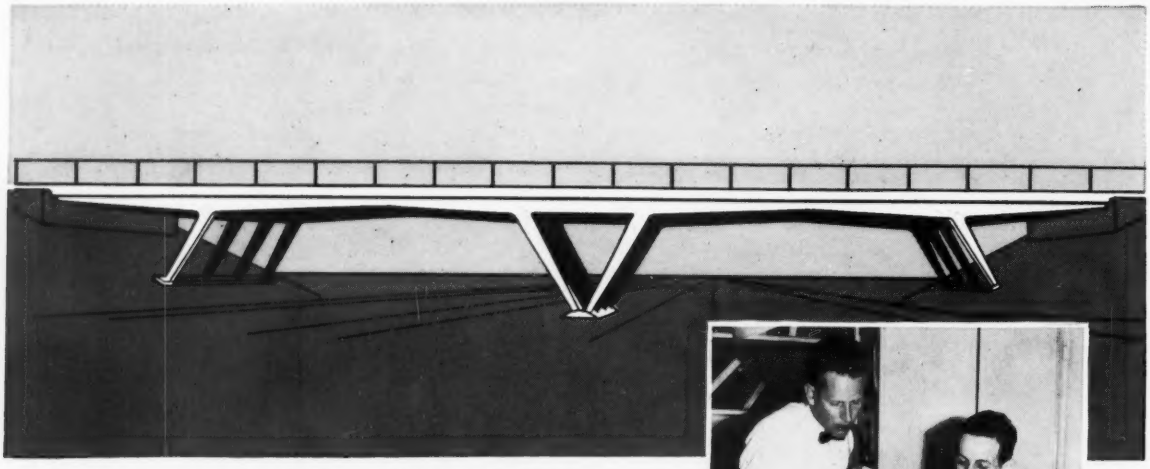
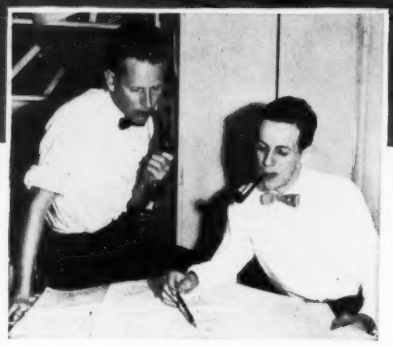
COLLEGE OF ENGINEERING
VOL. 25, NO. 3 DECEMBER, 1959

CORNELL UNIVERSITY
25 CENTS

surveying
past
and
present

the Cornell engineer





1st Award—$4,000—Student Class

Niels Jorgen Gimsing, Hattensens Alle 11, Copenhagen, Denmark
Technical University of Copenhagen (Graduate)
and
Hans Nyvold, Ulrikkenborg, Alle 62, Lyngby, Denmark
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University of Missouri School of Mines and Metallurgy (Graduate)

3rd Honorable Mention—$500
Student Class
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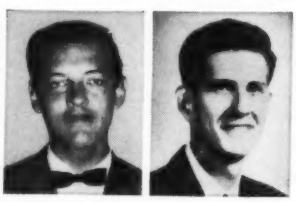
South Dakota State College (Graduate)



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Student Class
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Drexel Institute of Tech. (Graduates) Philadelphia, Pa.

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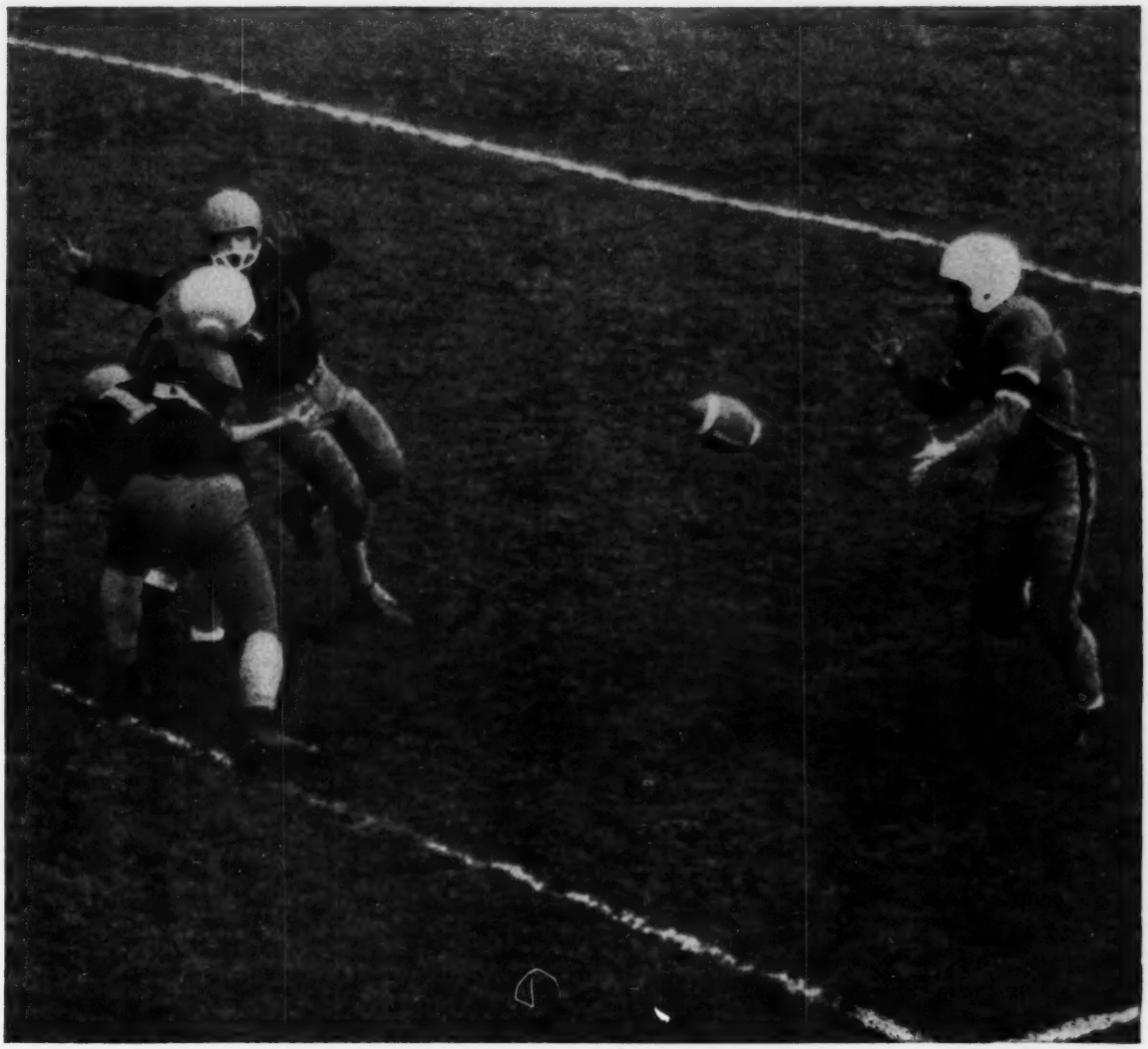

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Editorial . . .

WHY ARE YOU STUDYING ENGINEERING?

Do you enjoy what you are doing? Have you ever really given yourself a chance to find out?

If these questions were put to today's engineering students, many would immediately answer the first one no and then, after some thought, discover that they would probably have to answer the second one no, also. Characteristically, these students are all quite bored and dissatisfied with their school work, but they don't know why. The chances are good they just blame it on the nature of engineering.

Symptoms of Attitude

The general symptoms of this feeling are common to any observer. Participation in outside activities concerned with the College of Engineering, such as E-Day and student branches of technical societies is poor. Even more important, interest in courses is low among these students. The students do their work, they pass their courses, but they are not curious. They don't ask why or how when it is not necessary. Any extra work or effort, unless it is toward getting a better grade is frowned upon. One professor, in comparing today's students with those of the thirties and with the veterans just after World War II, said that they have as much if not more intelligence and ability than the previous groups; however, their interest in their work is completely lacking.

Many engineering students maintain a feeling, common, it seems, in many other fields of study, that school is an evil necessary for the attainment of a diploma. They are attracted by the high salaries available and are waiting for the day when they too will be able to receive them. Their diploma is the key to this small fortune and their studies at Cornell are treated like a tour of duty in the Army, counting the days until they get out.

Causes of Attitude

What has caused this basic change in attitude of engineering students? Before the Korean War, the only reasons most people had for studying engineering was desire and interest. They wanted to learn and were interested in finding out about the profession they were joining. This has all changed. The country's political position and international policies have made it almost a patriotic duty, for all those qualified, to study engineering and science. This call has been reinforced by industries waving large salaries and glamorous opportunities before the graduating seniors. This recruiting program has had much success in the sense that it has attracted students to the profession who would not ordinarily have considered entering it. And this is welcome because the country does need many engineers, as many as it can get, to meet its continuously expanding needs.

But these people are being attracted to engineering for the wrong reasons and therein lies their dissatisfaction with their studies. They are interested only in the side attractions which engineering has to offer, a high starting salary, a short route to management, and sometimes glamour. They are not attracted by the desire and interest, which years ago was the sole motivating force.

Missing Attributes

Three basic attributes are missing in this whole picture: curiosity, creative imagination, and initiative. These, in addition to proficiency in mathematics and science, are the basic qualities a person must have to become an engineer. Good ability in these last two is probably the main reason why most of today's engineering students had been influenced in high school to choose to study engineering. However, curiosity, creative imagination and initiative must be developed by most students while in college. They are not taught in any courses. As a matter of fact, they are hardly mentioned throughout all of the college work. Nevertheless, they are basic to the whole idea of engineering and it is through them that the engineering student will acquire a desire for studying and an interest in his work.

Curiosity is needed to find out what is going on, why, and how. Creative imagination is needed to see the relationship between various phases of work and how one phase can apply to the other. Only if he is able to see and understand this will his course work have meaning. These two qualities can only be and must be developed by each student himself. Initiative serves as an important aid and requisite in this development. A student needs it if he is going to help himself and give himself a chance to find and develop his interests. The three are, therefore, all closely tied together. They are all an integral part of an engineering education. In essence, they are engineering.

There is no reason why a person should not enjoy what he is doing, especially if he hopes to make a career out of it. Try to develop an interest in your work. You will never regret it. D.L.

Founded in 1885

THE CORNELL

engineer

DECEMBER 1959 VOLUME 25 NO. 3

Cover design by Leonides Ioannou, CE '63, depicts the dioptra, a surveying instrument of Greek origin.

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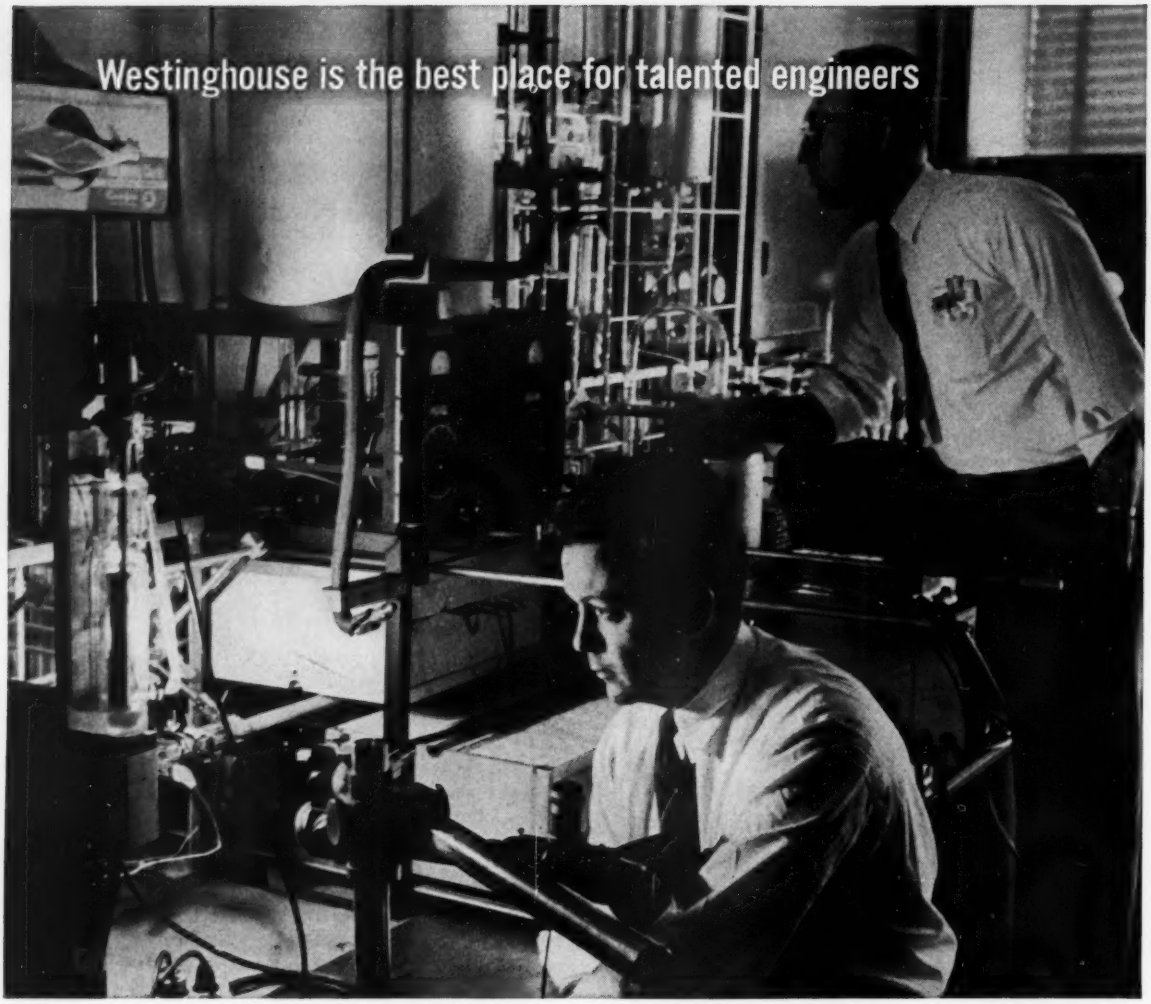

Westinghouse Metallurgists, Dr. M. J. Fraser (foreground) and Dr. H. W. Weart, prepare to photograph a molten alloy sample as one step in the determination of liquid-solid interfacial energy. These direct experimental measurements are the first of their kind ever attempted.

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Cubits to Cross hairs . . .

SURVEYING THROUGH THE AGES

by Mary Ann Huber, CE '63

The art of surveying as the engineer of today knows it consists of making measurements with the greatest possible speed and accuracy. However, the art whose development has enabled the surveyor to measure angles to fractions of a second has roots as old as mankind itself and has evolved from the most primitive methods of measurement.

The earliest attempts at a crude form of surveying arose as a natural outgrowth of man's desire to know the size of his personal property. In the primitive agricultural society, men wished to measure the boundaries of their fields and grazing lands. Often this was accomplished by the use of very flexible standards, such as a number of paces or a day's march. Man's body also served as a yardstick, and he used his height, his hands, and his feet as standards for measuring household objects and weapons.

As society became more organized, there arose a need to standardize certain measures in order to avoid disputes. The first known agreements of this kind took place around 6,000 B.C. in Egypt and Chaldea. Egypt was responsible for the standardization of the cubit two thousand years later, when the length was agreed upon as the equivalent of 18.24 of today's inches. This measure was used in the construction of ancient Egypt's famous buildings, including the pyramids, whose perimeters are exactly 2000 cubits.

The introduction of standardized measurements enabled man to draw maps and plans for his buildings. The Bible tells the story of Joshua's division of New Canaan in which some sort of crude map must have been used. The construction of the Tabernacle at Jerusalem must also have required a plan or layout based on measurements and drawings of the site.

Man soon began to divide his basic units of measurement into smaller units. Most of these divisions were one-twelfth or one-sixteenth of the original length unit, since man relied on divisions he could match with dimensions of his body, rather than on a decimal system. Religion also played a part in the establishment of subdivisional measurements. The Chaldeans, who worshipped the numbers 6, sixty, etc., originated the division of the circle into the same 360 degrees we know today.

Many of man's ancient surveys were directed toward measuring the earth itself. The Greeks recognized the fact that the earth is nearly round, and Eratosthenes made some calculations to determine its size by observing the angle of the sun's elevation at different latitudes. Due to the crudeness of his instruments, however, his calculations were somewhat in error.

Ancient Surveying Instruments

Among the early instruments used by the ancients for measurement and determining position on the earth's surface were the scaph and the astrolabe. The scaph provided the first means of measuring angles directly. It consisted of a hemispherical bowl, with a central upright rod whose height was equal to the radius of the bowl. Semicircles were drawn at regular intervals around the interior of the bowl, and the angle of altitude could be determined from the shadow of the rod.

The astrolabe gave the ancients a means of determining bearing and direction. Its invention about 150 B.C. is credited to Hipparchus. The instrument consisted of a heavy metal disc, averaging about one foot in diameter, suspended by a ring or three strings. At the center was pivoted the sighting ruler. The angle of altitude was measured off around the circle. The accuracy of this instrument was limited since the vernier had not as yet been invented.

Not until the seventeenth century did any further outstanding developments in the art of surveying take place. The early part of that century saw the introduction of triangulation as a method of geographical surveying. With the increased demand for oriental goods, European rulers sponsored voyages of exploration which greatly increased geographical knowledge and resulted in improved map making. Prince Henry and King John II of Portugal were outstanding advocates of these voyages.

The seventeenth century also saw the invention of the cross staff, another simple device for measuring angles of elevation. This instrument was a wooden bar, which was to be held by the observer. Another shorter bar was fitted at right angles to the first, but was free to slide back and forth. The second bar was aligned so that it seemed to "fill" the observed distance between the plane level with the eye and the sun or other heavenly body being observed.

In 1630, Francis Vernier gave science one of its most useful measuring tools, the device which bears his name. The vernier made pos-

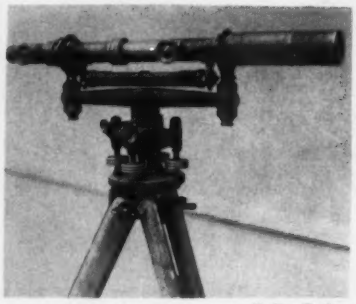
Benson Simon

The author adjusts a dumpy level during a surveying exercise on the Library Slope.

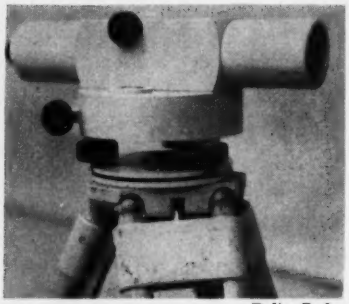
sible measurements more accurate by far than any made previously. The vernier consists of an auxiliary scale which is moved along an attached main scale. Each division on the vernier scale is smaller than a division on the main scale by the reciprocal of the smallest division on that scale. For instance, if the smallest division of the main scale of a transit vernier reads thirty minutes, each graduation of the vernier scale will be one-thirtieth smaller than a main division graduation, so that the vernier has thirty divisions for every twenty-nine on the main scale. The vernier reading is taken at the point where the lines on the vernier and the main scale align with each other.

The art of surveying had not developed exclusively in Europe at this time. There are records of a remarkable survey of Japan made in the late 1700's by Chukei. He used an azimuth instrument for determining horizontal angles, and a compass accurate to ten minutes of direction.

Chukei's azimuth instrument, however, was not without a parallel in Europe, for in 1571, Leonard Digges had developed the first "theodolitus", the ancestor of today's transits and theodolites. It was designed to measure both horizontal and vertical angles, just as present instruments do, and consisted of a vertical circle which was inserted into the horizontal circle as the instrument was assembled for use. After the introduction of the vernier greater accuracy was possible and improvements were constantly made upon Digges' original instrument. Some of the early theodolites used only horizontal circles, however, and an instrument of this type was used by Mason and Dixon in their famous American survey. Machine graduating of the circles was first used in the making of the Ranssden transit.



Delia Corkey



Delia Corkey

Comparison of a Gurley level, manufactured in the 1920's, and a Zeiss N2 self-leveling exemplifies progress in streamlining and instrumentation during the past several decades.

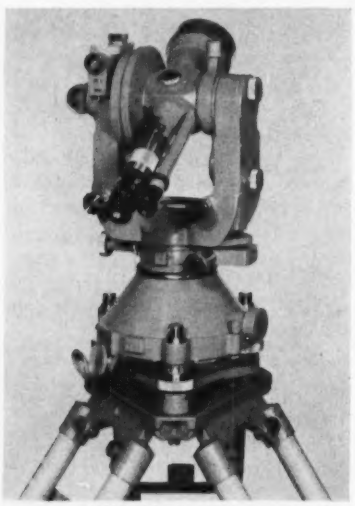
Surveying in America

Civil engineering had not made very rapid strides in America by the early 1800's. Public works, especially transportation facilities, were in a very primitive state of development, since no railroads existed, and very few canals, turnpikes, and bridges had been opened. Very few colleges taught engineering as a professional course, and consequently the country sorely lacked the trained civil engineers needed for the development of its steadily growing territory. The art of surveying was practiced as an avocation by some of America's noted men of the time. Certainly the most famous is George Washington; among others pursuing the art in their free time was President Stiles of Yale University.

The infant nation also boasted several famous professional surveyors at the time. One of the most prominent was David Rittenhouse. Rittenhouse combined several fields related to surveying in his professional duties. He was an authority on astronomy as well as a maker of surveying instruments and a conductor of actual surveys. Acting in this capacity, he fixed the first point for the Mason and Dixon survey, and some of the state boundaries.

A second noteworthy surveyor of the early nineteenth century was Andrew Ellicott. Ellicott conducted the original survey of the site of Washington, D.C. and was first to fill the post of Surveyor-General of the United States.

Early in its history, the United States began extensive surveys of its territories. About 1790, the geographer of the United States initiated surveys in the midwest, north of the Ohio River. These surveys were later extended and in 1812 came under the auspices of the General Land Office within the Department of the Treasury, later being transferred to the jurisdiction of the Department of the Interior when that department was established. In 1946 the Bureau of Land Management took over these functions. Public land surveys still adhere closely to the original ordinances governing land distribution set down by Congress in 1785. The system of location used in the systematic survey of land tracts by the government insures a complete



Wild Heerbrugg Instruments, Inc.

The Wild T3 precision theodolite gives horizontal angle measurements accurate to within 0.2 seconds, and has a useful range of twenty to sixty miles.

A theodolite manufactured by Elliot Brothers, London, in the mid-nineteenth century shows similarity to those in general use by engineers today in its use of an exterior horizontal circle and verniers.

and accurate identification of every land parcel purchased from the United States.

The United States has also established two fundamental control systems for use in surveys. These are the triangulation network and the U.S. Coast and Geodetic Survey level net. The former also ties in with Canada's and Mexico's triangulation nets. For easy general use of its triangulation net the Coast and Geodetic Survey has established state co-ordinate systems, giving each state its standard horizontal datum plane. The Coast and Geodetic Survey, in establishing its level net, has left permanent benchmarks at various points, which serve as standard elevations for reference in local surveys. This phase of the Survey's work is never complete, since many thousands of benchmarks are lost every year through careless construction practices and removal by thoughtless souvenir hunters.

Development of Instruments

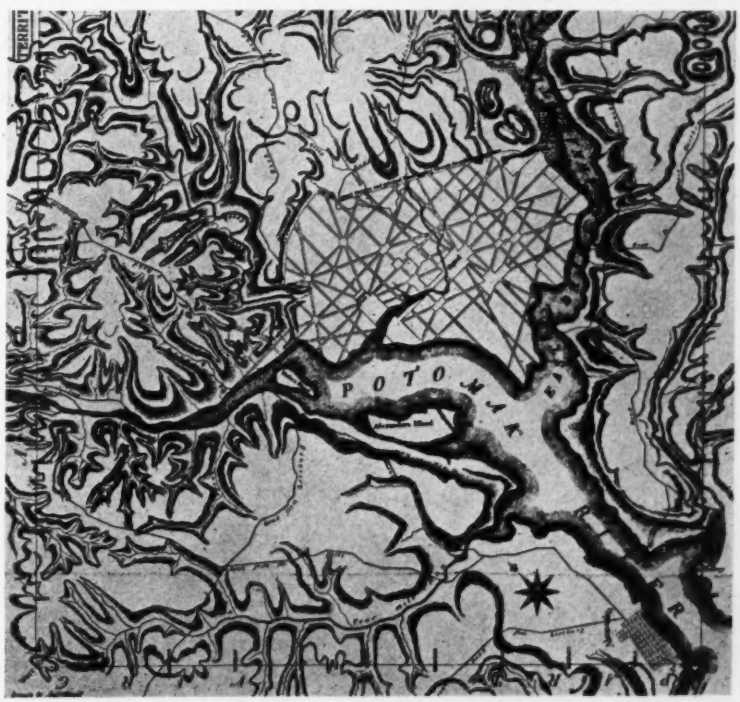
Instruments, as well as survey methods, have undergone considerable changes from their earlier forms. Since the principles of operation have tended to remain the same in transits and levels, many of the changes have involved the use of new materials to reduce bulk and the development of devices for making use of the instruments easier.

Two major innovations in the practice of leveling have been the introduction of the self-leveling level and the self-reading rod. The self-leveling level, perhaps the most outstanding instrumental development in surveying since the introduction of the transit, accomplishes its purpose by an arrangement of prisms inside the telescope. When the operator brings the instrument approximately level, a small prism called the compensator comes free from its stops and becomes stationary in its natural position through air-damping. Since the compensator swings back and forth as the telescope is tilted, it is free to change its position in such a way that it reflects a level line of sight in combination with two stationary mirror prisms. This instrument not only saves time and effort on the surveyor's part, but it improves accuracy by eliminating human error in the leveling process.

The self-reading rod gives the surveyor another time-saving tool in his trade. The rod is extendable and fashioned of two pieces of wood, similar to those of the ordinary Philadelphia rod. The graduations, instead of being fixed, are imprinted upon a tape which may move as a continuous belt around the length of the rod. When beginning a survey, the rod is placed on a permanent benchmark. The level is set up and adjusted, and then trained upon the rod. The levelman gives the rodman the reading at the point which coincides with the horizontal crosshair of the level. The place on the tape indicating the last few digits of the actual benchmark elevation is then moved to that point. For instance, if the elevation is 517.24, the rod would be set as close as possible to a reading of 7.24. The graduations on the rod read from top to bottom, since if the rod is lower than the benchmark elevation, the crosshairs will fall above the point originally set. The self-reading rod completely eliminates the need for computations in the level notes, since it reads the exact elevation of points. On the other hand, the rod has several disadvantages. It introduces human error in the original setting of the rod, and it requires frequent resetting when used on terrain where elevations vary more than about twelve feet. Because of this, it is generally used only in rather small surveys.

Although the basic structure of the transit has changed very little, instruments have been made more and more accurate over the years. Although the more common transits in use today have thirty or twenty second verniers, precise theodolites are available that read as close as fractions of seconds. These readings are accomplished by means of micrometers seen through a small viewer at the side of the telescope. Another innovation used on most foreign-made transits and leveling devices is the use of three leveling screws instead of the usual four. This arrangement permits easier adjustment of the instrument.

What does the future hold for an art that has developed to such a degree of accuracy? The dawn of the space age offers unlimited possibilities for the use of surveying. It may well be that within the next century man will find it necessary to develop new instruments to deal with yet unheard-of geographical conditions, and set off into space with whole new worlds to survey.



This topographical map of the District of Columbia was made by Andrew Ellicott, who conducted the preliminary surveys of the site in 1791.

Mapping Becomes Faster, Less Expensive, And More Accurate With...

ELECTRONIC SURVEYING

by Alan S. Rosenthal, EE '60

Reprinted from ELECTRONICS, Oct. 23, 1959

Electronic advances continue to have major effects on every phase of engineering. Recent developments in surveying equipment and techniques have significantly changed a basic civil engineering operation opening an important new market to electronic instrument manufacturers.

Geodimeters, tellurometers and many other devices are making it possible to survey areas that were formerly considered inaccessible and are cutting working time substantially. Computers are bringing drastic reductions in data-processing time.

Geodimeter Operation

Surveying and map-making operations require distance measurements to be far more accurate than those possible with ordinary radar techniques. The geodimeter gives this accuracy using modulated visible light to measure the distance between two stations. The geodimeter is an optical phase comparison system used at night. A block diagram is shown in Fig. 1.

Visible light is passed through a Kerr cell and reflected from a distant target. The Kerr cell is an electronic shutter that marks the beam for phase comparison. It is a glass vessel containing highly purified nitrobenzene between two electrodes. The application of a voltage to the electrodes orients the dipole molecules of the fluid in the direction of the field. As a result, the cell's refractive properties are a function of the applied voltage. In the geodimeter, a d-c reference voltage with an a-c signal superimposed upon it is applied to the cell; thus, the light beam that passes through is modulated.

The same a-c signal that is applied to the Kerr cell is used to power the multiplier phototube. The circuit is so designed that the tube is operative only when the modulated light is at a zero point. The action of the phototube must be synchronized with the light signal. Delays caused by finite wire lengths are compensated for by the variable light-delay unit inside the geodimeter. This delay unit permits accurate calibration before measurements are made.

The geodimeter's oscillator is designed to operate at 10 mc. The resulting half wavelength is 15 m. If the reflector is moved 7.5 m to the position shown in Fig. 2B, the phototube will still record a null. But moving the reflector a smaller distance, d, makes it necessary to move the phototube an equivalent distance for a null reading as in Fig. 2C.

The variable electrical delay unit has the effect of repositioning the receiver. The delay unit is calibrated so that when a null is obtained the dial gives a direct distance reading corresponding to the delay introduced in the phototube response.

This reading alone would only give the fraction of 7.5 m lengths between the transmitter and reflector. A provision for varying the frequency slightly and again determining the null gives the number of half wavelengths in the measured distance.

Tellurometer

Another distance measuring device working on similar principles is the tellurometer. Instead of using

Cubic Corporation

Micro-dist is being used to make a measurement for one of California's highways. The portable instrument is easy to use and provides the necessary accuracy.

Eel River survey in northern California used a helicopter to transport microwave distance measuring equipment. Use of the instrument in the survey conducted by California's Department of Water Resources, resulted in an estimated 50 per cent savings. The helicopter made even further economy possible.
McGraw-Hill

visible light waves, it operates with microwaves. In this instrument, the null detector is replaced by a cathode-ray tube from which the desired distance may be read.

Since the tellurometer does not use visible light, it does not demand the night operation required by the geodimeter. It can be used under unfavorable weather conditions, but its accuracy is then reduced because of wave refraction by the atmosphere.

Advantages and Limitations

Both of these devices have been used extensively in precise surveying and mapping work. Users report highly sucessful operation with accurate results. The units not only save a great deal of surveying time but also open areas that had proven inaccessible to conventional techniques.

The range of the geodimeter can be as great as 20 miles. The accuracy of these electronic surveying instruments, while adequate for most operations, is limited primarily by atmospheric diffraction of the measuring wave. In each of the systems described, careful temperature and pressure measurements must be made and appropriate distance corrections applied. The corrections become particularly important when using the tellurometer.

The United States Air Force has been doing a considerable amount of research on this problem of atmospheric wave diffraction. Results show that frequent measurements of atmospheric conditions made between the receiver and reflector significantly improve accuracy.

Air Surveying

The use of electronic distance measuring techniques in ground equipment has been an important aid in surveying operations. When electronic surveying is carried on from the air, areas formerly considered inaccessible can be explored and mapped. Aircraft have been used to transport ground equipment from station to station, but electronic circuits now make it possible to use the airplane as an intrinsic part of the measuring procedure. Such operations are often coupled with air photographing.

The shoran system and its more accurate modification, hiran, are designed for such work. In these systems two portable ground stations are used in conjunction with an airborne receiver, transmitter and timing unit. The airborne transmitter sends out two 0.8 microsecond pulses at a repetition rate of 931 pulses per second on two frequencies in the 220 to 260 mc band. One frequency is used for each ground station, and the transmitter is switched from one frequency to the other at 20 cps.

Each ground station is a respond-

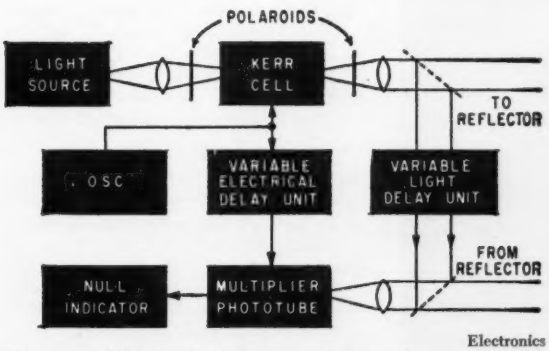


Fig. 1. Visible-light distance measuring circuit uses a crystal oscilator to power the Kerr cell and the multiplier phototube through a variable electrical delay. The variable light delay inside the instrument is calibrated to compensate for significant electric delays.

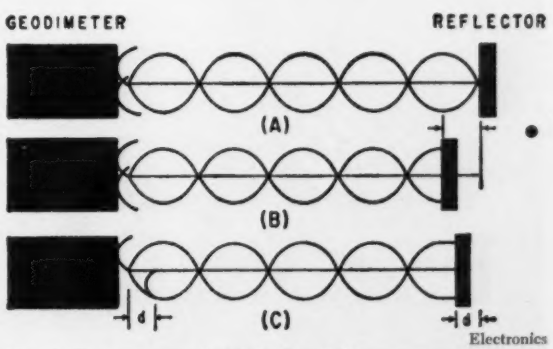


Fig. 2. The wave produced by the light source and Kerr cell has a wavelength of 10 m. When the reflector is moved some fraction of 2.5 m, a null is no longer recorded. A mechanical movement shown in (C) or an electrical one brings back the null reading.

er beacon which amplifies and retransmits a signal on a common frequency in the 220 to 320 mc band. These pulses are returned to the airborne unit, and the time between the interrogation and response pulse is interpreted in terms of distance.

The circuit is designed to provide a continuous record of the distance from the plane to each station. Instead of actually measuring time or distance from transmitted to received pulse, the system makes the received pulse coincide with a reference pulse.

The hiran system introduces several modifications to the basic shoran distance determination method. The size of all electronic components is reduced for greater portability. The improved circuits are designed to decrease pulse rise time and increase pulse amplitude. Another step to improve operation is the reduction of interference and physical variables in the unit.

Electronic Map-Making

When air photographs are taken, electronic circuits play an important part in the processing procedure. New developments in this area include stereo-plotters that produce contour lines and topographical maps directly from air photographs. Although many of these units require a skilled operator and are still in the developmental stage, when available, they will be major time and labor savers.

A completely new approach to the field of air mapping is the use of air-carried gravity meters to determine topography. Since local changes in the shape of the earth cause changes in gravitational force, measurement of these changes provides useful data for map making.

The meter uses an oscillating spring to determine the gravitational force. The equation, $\ddot{x}+R\dot{x}+kx=(g+a)+Ky$ in which g=gravity, Ky=spring tension adjustment, a=housing acceleration and $\ddot{x}+R\dot{x}+kx$=spring correction, where x is the vertical position of the spring, is basic to the gravity measurement. By measuring the spring tension and housing acceleration and using an analog computer to determine the spring correction, it is possible to determine the value of Ky quickly with no need to wait for the spring to come to rest.

Two major difficulties which this technique encounters are meter stabilization and the determination of aircraft motion and position. Gyro systems provide some stabilization, but airplane position and acceleration must be carefully noted. Although data may be taken under normal flying conditions, excessive air turbulence invalidates the observation. Aircraft position must be accurately determined, and systems such as hiran or doppler radar in conjunction with pressure altimeters are usually used.

A major disadvantage of most of these air-surveying techniques is a loss of accuracy. The accuracy of the results cannot compare with those of ground methods, but the speed with which an area can be mapped and the ease with which it can be reached make the method valuable, especially for military work.

Computers

New electronic equipment is thus playing an ever-increasing role in gathering survey data and translating them into maps. Not to be neglected are the many uses for computers in the processing of these data. Digital computers are used for checking traverses for geometrical closure and adjusting angular errors, for computing adjusted bearings and trial closures, and for computing plane coordinates. Computers have repeatedly proven their value by making possible the thorough and accurate evaluation of large quantities of data. Despite high rental costs, surveying companies find that for organized operations of sufficient size, the use of computers is economically justified.

Cubic Corporation

Micro-dist uses radio-frequency signal to measure distances. Two interchangeable stations are used with one acting as an interrogator and the other as a responder. The time lapse between the original pulse and the return signal gives a measure of distance.

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The Search For New Reserves Finds Industry Seeking . . .

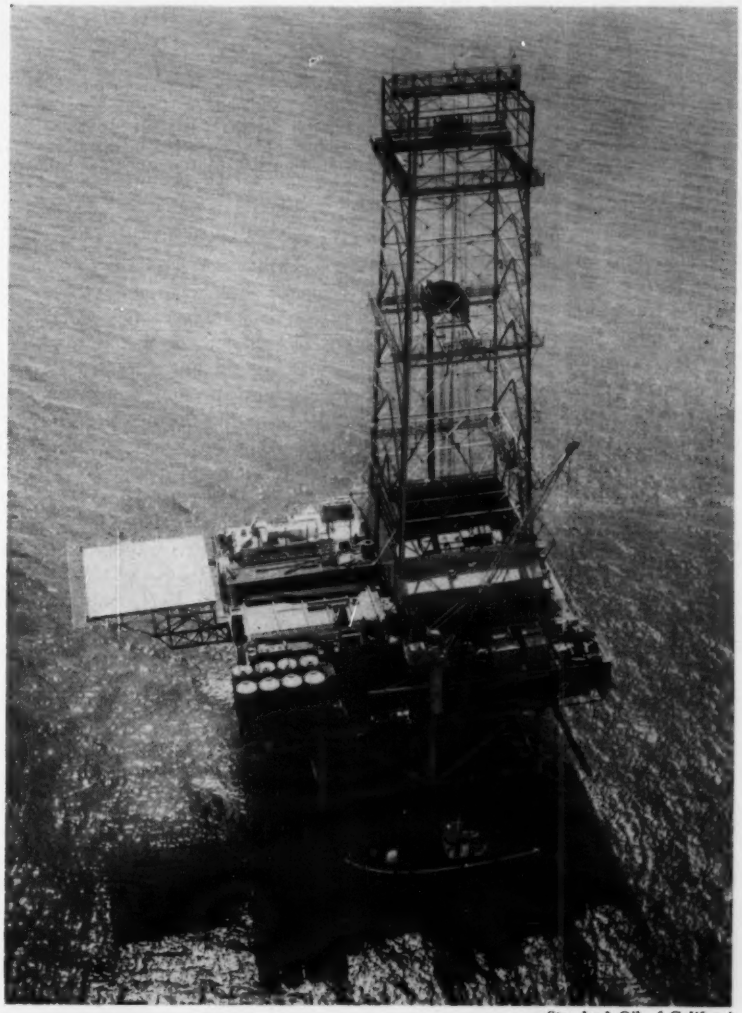
OIL BENEATH THE SEA

by Harry J. Green, III, ChemE '63

After decades of abundant oil consumption, the United States has finally discovered that the resources of oil in this country are dangerously depleted; a new source is necessary. Faced with the responsibility of acquiring enough oil for our needs, the oil industry is turning towards the land beneath the sea where it is estimated that billions of barrels of crude petroleum are waiting to be found. This tremendous potential has led to the formation and rapid growth of a whole new business, offshore oil drilling.

Oil beneath the sea is found under the United States Continental Shelf, a land mass lying submerged in less than six hundred feet of water. A particular portion of this shelf, the Continental Shelf of the Gulf of Mexico covering one hundred twenty-nine thousand square miles, is the chief location of exploration, drilling, and production efforts of United States oil companies. This underwater land strip extends from the southern tip of Florida around to the tip of the Yucatan peninsula.

Offshore development in the Gulf of Mexico was predicted before extensive developments of inland bays and shoreline locations began in the early thirties. The Texas Company was among the first to experiment in this field with their development in the open water and bordering marshes of coastal Louisiana, opened in 1929–1930. Although the drilling was done in up to ten to twelve feet of water, the installations were considered sheltered from storms and high waves or swells. The first true offshore well was located over a mile out in the Gulf at a point southeast of Cameron, La. This field was brought in by Superior Oil Company and Pure Oil Company in 1937 by the drilling of ten

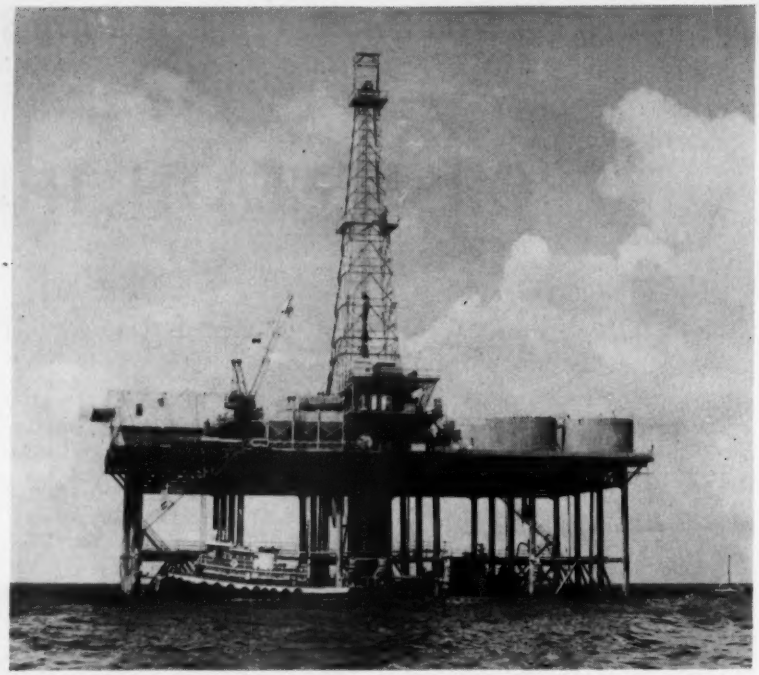


Standard Oil of California

An important oil discovery was made recently near Summerland, 9 miles southeast of Santa Barbara, California. This exploratory well flowed clean oil of 36 degrees at the rate of 867 barrels an hour during a brief test. The platform from which the well was drilled stands in 100 feet of water and cost more than three million dollars.

wells from one platform in water thirteen feet deep at mean low tide. The utilization of this method resulted in extensive exploitation of oil reserves of the Gulf of Mexico and of bays along the Texas coast during the first part of 1938. Standard Oil of Texas brought in a well in Galveston Bay about a mile offshore during February 1938. Offshore ventures by Humble Oil and Refining Company and British-American Oil Producing Company followed.

However, it wasn't until after World War II that the oil companies began to sink vast sums of money into offshore exploration and drilling. Magnolia Petroleum Company was the first to invade distant offshore water when they drilled a well ten miles off the Louisiana coast in August 1946. In 1947 an important oil discovery was made by Kerr-McGee Oil Industries, Inc., in the Ship Shoal area, Terrebonne Parish, Louisiana. This was followed by the Humble Oil Company discovery in the Grand Isle area, Jefferson Parish, Louisiana. Many other companies began sending out exploration teams to find prospective oil producing areas and then leasing the various tracts of land at state lease sales. Today there are more than forty-five companies or operators, acting in their own behalf or together in groups, engaged in exploration, drilling, and production in the Gulf of Mexico. The daily oil production off the Louisiana and Texas coasts is almost sixty-three thousand barrels. Estimates have established the total recoverable reserves to be fifteen billion barrels. The enormous potential supply of oil has induced the oil companies to lease over 3.3 million offshore acres in this area.



This $1,500,000 CATC stationary drilling platform in the Grand Isle area off Louisiana towers 58 feet above the water. Measuring 220 feet by 106 feet, it sits on 300 foot pilings, each 30 inches in diameter. A veritable oil community in the Gulf, it has air-conditioned living quarters and helicopter landing deck at left and storage facilities at the right of the rig.

Combines Protect Companies

When an oil company decides to explore for oil beneath the sea, it is getting itself into an operation involving the expenditure of millions of dollars, and possibly the loss of millions of dollars. To reduce this great risk many companies have formed large combines to spread the cost of offshore drilling. The largest of these combines is CATC, consisting of Continental Oil Company, the operator; Atlantic Refining Company; Tide Water Associated Oil Company; and Cities Service Oil Company. Each of these companies holds 25 per cent interest. They each put up 25 per cent of the money necessary to begin operations, and then, using the men of Continental Oil Company, the operator for the group, they send out a geophysical exploration team.

Geophysical prospecting has made great strides since World War II. At first, seismograph work did not extend beyond three miles from shore. In 1944, Superior Oil Company extended the frontier of workable seismograph territory in open water to twenty-six miles. However, seismograph parties have improved their water technique so much that is is now cheaper to chart a broad area in the Gulf than a similar area on land. But the seismo parties still face problems. A seismo crew must know just where it is when its shots are detonated below the surface of the water. To solve this problem radar is used to pinpoint locations when the crew is beyond the sight of land. The problem of locating the geophones used to pick up reflections of the blast is solved by towing them along behind the shooting boat in a pre-arranged pattern.

A temporary problem that arose was the complaint of the native Louisiana fishermen and fishing communities that geophysical shooting was destroying their valuable shrimp and oyster beds. However, the differences were ironed out by hiring the fishermen to work on the exploration boats and allowing them to get an intimate knowledge of what was taking place. Town meetings, which were part of an education program involving state conservation agents, also aided in solving the dilemma.

Once preliminary geophysical work is done, the company must participate in state or federal lease sales to obtain the areas they think contain prospective oil fields. At this time, expenses begin to mount. Oil companies have spent as much as 7.5 million dollars for a five thousand acre tract, or one thousand five hundred dollars an acre. The states of Louisiana and Texas have taken in over one hundred fifty million dollars as a result of lease sales, and the federal government has taken in two hundred fifty-two million dollars as a result of its sales. The bidding process for these five year leases is a compli-

cated one and involves taking gambles. Offshore operators figure out how much a certain lease is worth and then prepare a bid. Of course, each firm has its own process or method for figuring out bids, and these bids are sometimes refigured constantly right up to deadline time. Then comes the gamble. The sealed bids are opened and the highest bidder gets the lease. Some of the costs a company must figure in its bid for a federal lease are an annual three dollars an acre rental fee on the land, a one-sixth royalty on production, and a minimum bonus charge of fifteen dollars an acre. Texas has a minimum bonus ranging from five to fifteen dollars an acre, and a royalty fixed at one-sixth. Louisiana has neither a minimum bonus nor a set royalty, and the highest bonus bid generally gets the lease.

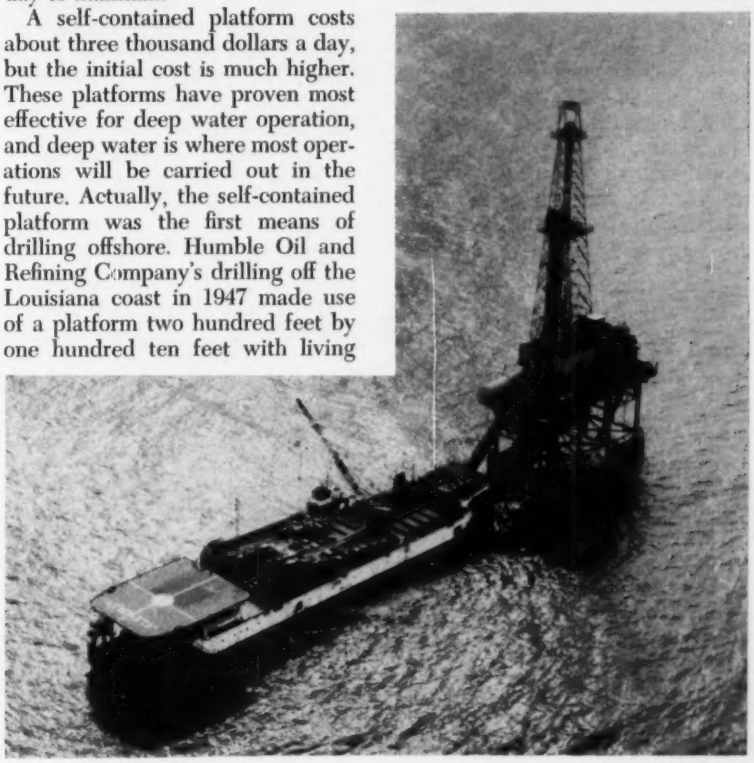
Careful and extensive geophysical prospecting is the first big chore facing the offshore operator after he gets his lease. This step is necessary to locate the first class salt-dome structures that mark prospective oil fields. It has been estimated that the geophysical cost in finding one of these domes averages over four hundred thousand dollars. Large as it may seem, though, this sum is small in comparison to the amount to be spent in getting the right kind of equipment on location to start drilling.

Equipment Costs Prohibitive

No matter how one handles the question of equipment, it is an expensive proposition. The offshore operator must decide whether to invest a quarter of a million dollars or so in a permanent template-type platform which can't be salvaged, or to rely on one of the newer type portable submersible units. Permanent template-type platforms are smaller in size than the self-contained type and they are cheaper to construct. However, they require the use of a tender ship which costs from 1.5 to 2.5 million dollars, depending upon its type and whether or not it is self-propelled. An example of the non-self propelled drilling tender is the CATC tender. This ship, approximately two hundred sixty feet long and fifty-four feet wide, provides "living quarters for forty men, helicopter landing decks, recreation rooms equipped with television, a modern galley kitchen and cafeteria, safety features including lifeboats and fire fighting systems, power units, and storage facilities for drill pipe, casing, drilling mud, fuel oil, cement, mud pumps, and other drilling supplies." [1] An example of the self propelled tender is the Humble ST-9. This boat is a converted navy landing ship which is three hundred twenty-seven feet long, fifty feet wide, and which weighs five thousand five hundred long tons. It has been converted to provide comfortably for the drilling crew and for storage of drill pipe, casing, drilling mud, and the other necessary materials. However, this combination of a template-type platform and a tender has the disadvantage of being subject to too much down-time because a rough sea keeps men and supplies from being transferred from smaller boats to the tender. Also, a combination such as this costs about five thousand dollars a day to maintain.

A self-contained platform costs about three thousand dollars a day, but the initial cost is much higher. These platforms have proven most effective for deep water operation, and deep water is where most operations will be carried out in the future. Actually, the self-contained platform was the first means of drilling offshore. Humble Oil and Refining Company's drilling off the Louisiana coast in 1947 made use of a platform two hundred feet by one hundred ten feet with living quarters for fifty-four men. It cost about 1.2 million dollars and is still in operation. Another example of a self-contained platform is the giant 1.5 million dollar platform owned and operated by CATC. This giant measures two hundred twenty feet by one hundred six feet and towers fifty-eight feet above the water. It is completely self-contained in that it has air-conditioned living quarters for forty men, a helicopter landing deck, and storage space.

The building of these steel monsters takes as much as two thousand five hundred tons of steel. They consist of "(1) steel piling, and (2) a lower jacket assembly, over which is placed (3) a top assembly containing the rig floor." [2] The platform's weight is supported by driving long steel pilings through the corners of the platform and deep into the solid soil beneath the surface of the water. However, when the platforms are brought out into deep water, additional support for the pilings is needed. This problem was solved by the engineers of Pure Oil Company working in conjunction with a hired oceanographer. They added a giant wheel, seven feet high and twelve feet in diameter, to the bottom of each pile. The main pile or support goes through



Cities Service Company

Drilling group in the West Delta area off the coast of Louisiana's plaquemines parish search for oil in the tidelands. The tender-platform team is one of the most popular methods of drilling in the Gulf of Mexico. The drilling tender serves as the warehouse, powerhouse, and hotel for the platform.

the center of the wheel, and a twenty-six inch piling is driven through the thirty inch support down to about eighty feet in the floor of the sea. In addition, four thirty inch piles are driven through four holes in a funnel at the bottom of the wheel until their tops are below the top of the wheel. Finally the wheel is filled with concrete. This means each thirty inch tower leg is supported by a twenty-six inch column and four additional thirty inch supports.

The use of mobile submersible barges and platforms is another method of drilling offshore, but the high cost of building and maintenance (eight to ten thousand dollars a day) keeps this process in the background. The barges can operate in only forty-five feet of water, but the platforms such as "Mr. Gus" can operate in water up to one hundred feet deep. The drilling operation of this platform consists of sinking a huge bottom hull to the ocean floor, and then driving steel pilings through it and anchoring them. When the well is drilled, the bottom hull is refloated, and its rise lifts the upper hull into a floating position.

The cost of all of these drilling platforms is just a part of the initial cost faced by an offshore operator. The high initial investment and the relatively low return has stopped many smaller companies from going into offshore drilling unless they combine their resources. Once a company has bought leases and begun drilling, it has to forget any oil field with less than a ten million barrel ultimate recovery because it can't expect to get its money back with such a small recovery.

Even weather often causes great expense — hurricanes can create costly damage, and general rough weather stops production by preventing men and supplies from being loaded on platforms. There is also the threat of fire, such as the one that struck the CATC platform causing losses of about 10 million dollars. This has resulted in companies spending around forty thousand dollars to equip a single platform with safety devices. Insurance premiums are also on the rise. Supply costs are high, both for the drilling materials and for the boats to carry them. Even if the company rents boats, it is an expensive operation. The cost of production of an offshore well is from two to five times the cost of an inland well, and once a company brings in a well, it is allowed by state law (for conservation purposes) to pump only a certain number of barrels per day based on the depth of the well. Then comes the cost of getting the oil to the shore. At the present time, it is shipped to shore in barges, but barges are often stopped by bad weather. Pipelines sound like the logical answer to this problem, and while it only costs about five cents to pipe a barrel to shore, the initial expense of laying pipe is about eighty thousand dollars a mile.

Appeal of Offshore Drilling

Why do companies take the risk of going offshore to seek oil? What makes companies so interested in offshore drilling when they know the oil industry has spent over two billion dollars in its search for offshore oil and it has gotten back only two hundred fifty million dollars? It is the great potential offshore drilling has, and the great increase in proper equipment available for the job. It was estimated in 1955 by Ben C. Belt,[3] retired vice president of Gulf Oil Corporation's Houston production division, that in five years crude oil reserves could be increased by six billion barrels by offshore drilling. Also, there pends the promise over that same period of time of increasing the natural gas production by as much as fifteen trillion cubic feet. In fact, production of offshore gas is outstripping crude oil production. Another reason for companies to step into offshore drilling is the indication that the high costs of leasing and producing offshore are starting to decrease.

The big reason for companies, even small ones, to begin offshore operations is the tailor-made specialized equipment that is now coming into use offshore. Already mentioned are the new mobile submersible barges and platforms. Also there are the new drilling rigs that, when installed on a permanent platform, can drill six wells without skidding. Two different methods of accomplishing this have been developed by California Company of New Orleans, and Shell Oil Company. Automation offshore is another possibility. Already Gulf Refining Company has experimented with radio controlled production facilities offshore, a system which enables one man to control the complete producing cycle by pushing buttons onshore. The intricate radio equipment necessary has a maximum effective range of seventy miles. Another automatic program is being planned by CATC. They have already installed and begun testing the massive microwave communications network necessary for the system. Furthermore, they are experimenting with a large wind power plant to power the communications system and eventually the entire automation system. This wind plant is a three-bladed steel propeller, thirty-three feet in diameter, coupled to a six kilowatt generator and a speed increasing transmission. It is mounted on a forty foot high tripod and is connected to a one-hundred-twenty-volt bank of batteries. The plant has already been used to power the necessary safety aids on the platform such as navigation lights and the continuously sounding foghorns.

Other new advances in the offshore business are special boats for every type of job, the use of helicopters for transportation of men and supplies, the use of Lorac (long-range accuracy), a type of radar-base navigational aid system, for locating boats up to seventy-five miles away, and the use of floating vessels for drilling purposes. The latter has been done successfully by CUSS (Continental, Union, Shell and Superior Oil Companies) and others.

All of these new advances are indications that the oil industry is in offshore operations for keeps. The possibility of increasing our crude oil reserves by 20 percent at a time when we need as much oil as possible is sufficient reason for oil companies to risk billions of dollars on offshore operations. There is no doubt that offshore oil drilling is a business of the future that will become increasingly more important to the economic health of our country.

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[1] "History of CATC Group," compiled by Continental Oil Company.

[2] "On the Continental Shelf: A Whole New Business is in the Making," *Petroleum Week*, Aug. 1955.

[3] *Ibid.*

Shorter Take-offs, Greater Economy, and Fewer Decibels From New . . .

TURBOFAN ENGINES

by Alden Speare, Jr., EP '63

One of the major drawbacks to the use of jet engines by commercial airlines is that jet-equipped aircraft require long take-off strips. At present only a few cities have airports large enough to accommodate the giant airliners. Pratt and Whitney Aircraft is contributing to the solution of this problem by developing a turbofan engine which enables aircraft to take off in approximately two-thirds the distance required by the present turbojet engine.

This new turbofan engine, which will go into production next summer, will not only boast more take-off power than the present jet engine but will offer speedier, more economical transportation and quieter take-offs.

The basic principle of the turbofan engine is a simple one. Instead of thrusting all of the air out the back of the jet at high temperature and high velocity, the engine releases a large part of the air in the front after it has been partially compressed. This method provides a thrust of greater air mass but lower air velocity, and makes the engine more efficient.

A conventional turbojet engine such as the Pratt and Whitney J57 is propelled by the thrust it obtains from burning fuels similar to kerosene in compressed air. The compressor in the front of the engine scoops up the air and forces it down a continually narrowing passage by means of a series of rapidly rotating blades, compressing it to approximately one-twelfth its original volume.

The compressed air is then forced into the burner section where it combines chemically with the fuel to produce hot gases that leave the burner at high velocity and ram against the turbine blades. This force rotates the turbine which in turn rotates the compressor on the same shaft. The gas then exits through the exhaust nozzle to provide the thrust to move the engine forward.

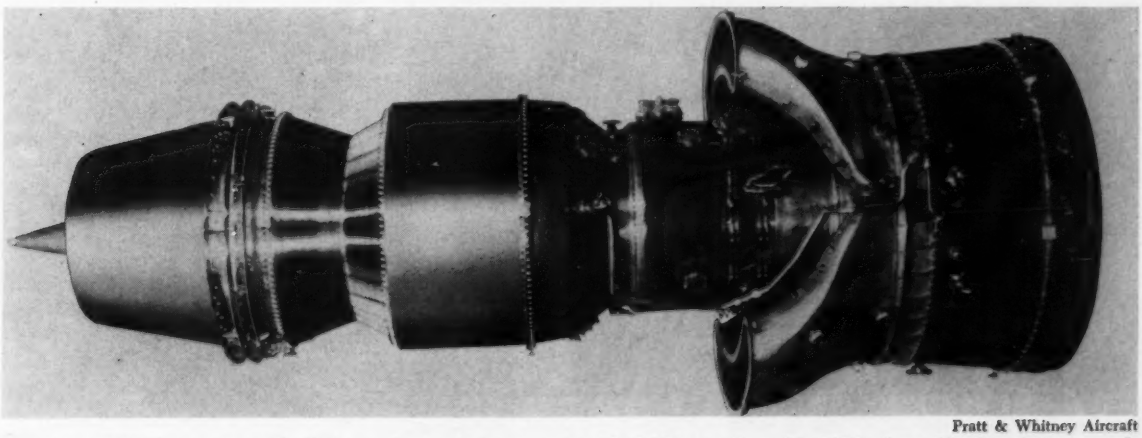
The J57 engine is built on a two spool layout. The inner spool contains the first nine of the low compressor stages and the last two turbine stages. The outer spool holds the seven high compressor stages and is driven by the first turbine stage. All sixteen compressor stages and the three turbine stages are made up of discs, which hold approximately one hundred blades on their circumference, and a set of stationary vanes that redirect the air for the blades of the next stage.

The Pratt and Whitney turbofan engine differs from the standard turbojet in that it has a fan section at the front which produces additional thrust. This fan section consists simply of two or three compressor stages which are larger in diameter than those of the rest of the engine and therefore propel with the tips of their blades the airstream surrounding the compressor. Air leaving the fan section is split, the inner portion of it going on to the engine's compressor and the outer portion exiting to produce thrust.

Based on Known Principle

The fan principle is not new with Pratt and Whitney and has been known for some time. General Electric also has developed a fan engine called the CP-805. This engine, however, uses an oversized turbine as an aft fan.

The first Pratt and Whitney fan engine, the JT-3D, was developed from the standard J-57 by making three major changes. The first three compressor stages were removed and replaced by two fan stages; the third turbine stage was enlarged and a fourth turbine stage added to provide extra power to drive the fan; and a short discharge duct was



Pratt & Whitney Aircraft

The entire JT3D fan engine with discharge ducts weighs approximately 3,900 pounds and is 147 in. long. The fan section propels around 140 per cent more air than that passing through the engine and greatly increases thrust at low speeds.

constructed to exhaust the air from the fan.

Fan Engine Has More Thrust, Greater Efficiency

With these few changes the engine became not only more suited to short take-offs and short distance flights but also more efficient for long distances and capable of longer range. The fan engine is a compromise between jet propulsion and propeller propulsion. Although not as efficient as the propeller engine, its 700mph maximum speed almost doubles the 400 mph limit of propeller aircraft and it is considerably more efficient at all speeds than the straight jet.

Tests show the JT-3D to have approximately 17,000 lbs. of dry take-off thrust compared to the 12,000 lbs. of thrust of the J-57 of comparable weight. Climb thrust is over 27% greater and cruise thrust is 20% greater. Specific fuel consumption ratings figured in lbs. of fuel per hour vs. lbs. of thrust are 15% lower.

The high noise level caused by the violent mixing of jet exhaust with stationary air is a major complaint of people living near jet airports. To their satisfaction, the noise level of the JT-3D has been reduced by around 10 decibels depending upon the ducting system used. Noise reduction is achieved because some violence of the jet exhaust is drained off by the extra turbine stage required to run the fan section and because the low velocity air from the fan section produces a blanketing effect.

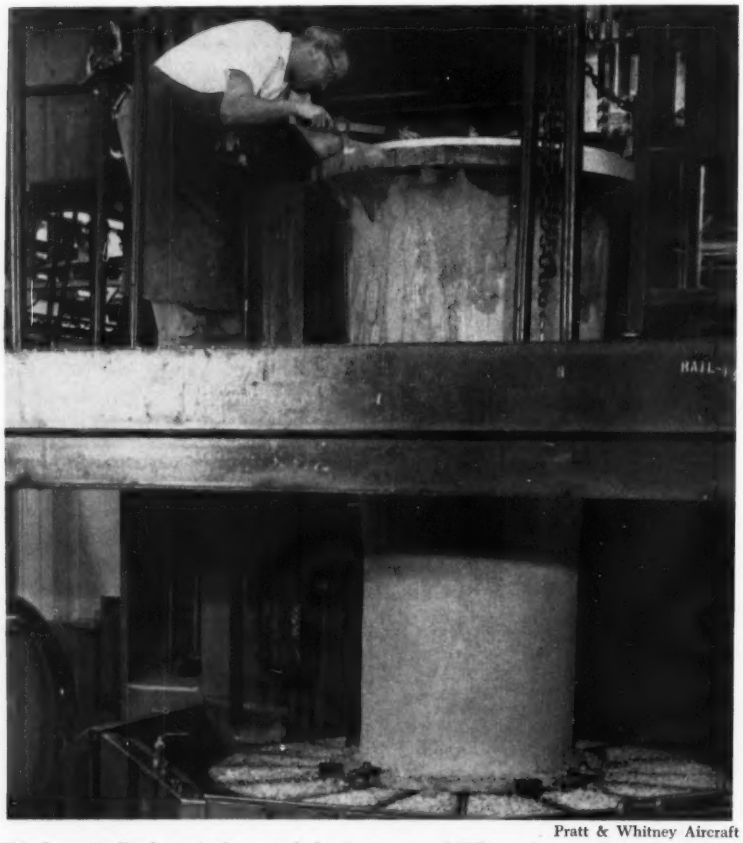
The JT-3D has been chosen for use in the new Boeing B-52H missile platform bomber. It will also power the Boeing 707 and the DC-8 commercial transports.

Designing the JT-3D

Many problems arise in designing a new type of jet engine. The compressor section, often called the heart of the engine, contains hundreds of small airfoils all rotating at high speeds. The blades and vanes must withstand great centrifugal force, vibration, extreme heat, and pressures up to 200 lbs. per square inch. The extra large 16-inch blades required for the fan stages proved even more of a design problem.

When a compressor is tested it is confined so that nothing can be seen. Test gauges at best record data for one operating condition at a time, and the sheer volume of calculation required to use this data to accurately estimate performance at more than one operating condition defies human ability.

Pratt and Whitney's computer center, which is one of the world's largest, offers solutions to many design problems. As soon as the JT-3D fan stages were designed, the design data were fed into one of the huge IBM 704 machines, and performance curves and data for both the individual stages and the entire section poured out in a matter of minutes. The machine predicted whether the blades and vanes would stand up under all specified operating conditions and calculated their natural resonance frequencies so that resonance could be avoided. Some of these calculations could not possibly have been performed by a man using a slide rule. Later test data substantiated the predicted performance that the IBM machines derived from the design information.



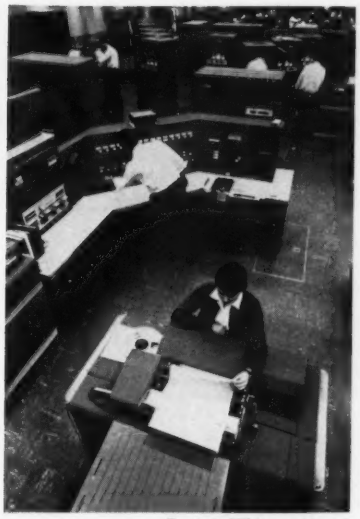
Pratt & Whitney Aircraft

This large Bullard vertical turret lathe in Pratt and Whitney's experimental machine shop has a platform which can be elevated to give the operator access to all parts of his workpiece.

Construction of an Experimental Engine Requires Tremendous Facilities

The construction of the first JT-3D engine, like the construction of the first engine of any new design, was a difficult and expensive task. The experimental machine shop and sheet metal shop both require very versatile machines and tools, and only highly skilled operators capable of making many difficult set-ups can be employed. The cost of tooling is high since even a minor change in dimensions requires new fixtures.

The large fan case for the JT-3D was machined in the experimental machine shop on a Bullard vertical turret lathe which is a huge lathe tipped on end to accommodate large parts. Some of these vertical turret lathes have elevated platforms to allow the operator to move up and down the height of the case. Short stubby lathes which were designed at Pratt and Whitney



Pratt & Whitney Aircraft

Test data can be analyzed in a matter of minutes on these hugh IBM machines, enabling test engineers to make changes while the engine is still running. The machines also handle the volume of calculations necessary for the design of an engine.

and are called T-lathes were used for machining large rings and vane assemblies that could be placed on a face plate.

Compressor and turbine blades with complex airfoils were machined on a duplicating machine which picks up contours from a master blade and duplicates them on blanks, six at a time. The master blades for these duplicators were milled on a master milling machine which can be electronically set for the airfoils of the blade.

The huge exit ducts were the largest pieces of metal ever to be formed by the company's drop hammer. The drop hammer process, although antiquated by the hydraulic presses, is still used in the experimental shop because dies can be made cheaply and easily out of lead, whereas press dies must be made from steel.

Inspection of parts often takes almost as much time as is required to make them. The compressor and turbine discs which hold the blades must be carefully checked. Slots that hold blades must meet close tolerances. The grain structure is brought out by acid etching and studied under a magnifying glass for any imperfections. Cracks are detected by a special process called Zyglo in which the disc is immersed in a penetrating oil containing a fluorescent alloy, quickly cleaned off, and then studied under ultraviolet light to pick up fluorescent oil seeping out of cracks. Blades and other small objects are often enlarged on a shadow graph for detailed study and close gauge measurements.

Parts completed in the experimental machine shop or purchased from outside are stored and recorded on IBM cards. When the time comes to build an experimental engine the parts are pulled from stores and delivered to the different subassembly sections of the assembly floor. The low compressor, the high compressor and the turbine are then assembled separately and dynamically balanced.

Various instrumentation is then installed. Wires are placed on blades to pick up the frequency of vibration when the engine is running. Small pressure diaphragms are installed in the sides of the cases to test pressure, and thermocouples are placed at different points in the engine and on all bearings and seals to record temperature. Dimensional measurements are also recorded for all parts of the assembly.

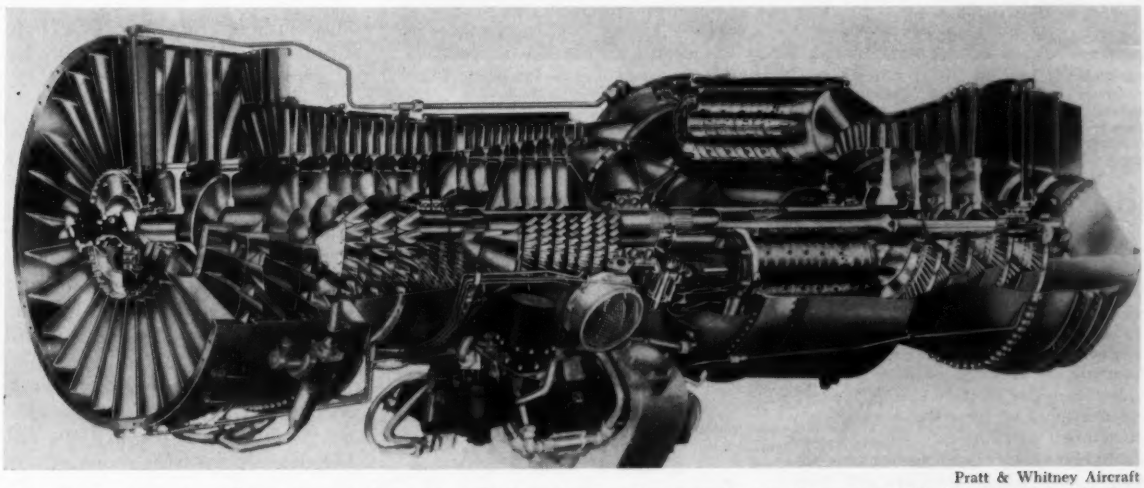
The entire engine is then assembled and the lubrication and fuel lines are installed. Many design errors are picked up and corrected on the experimental asembly floor before the engine is listed.

Test is Climax of Program

Pratt and Whitney's test facilities are the largest privately owned ones in the world. Most flight conditions can be simulated and thrust, temperature, and pressure recordings made that enable performance under any conditions to be calculated.

A normal engine is tested at sea level conditions with both intake and exhaust open to outside air.

Thrust is measured by pressure developed in hydraulic systems connecting the engine test stand to the floor. Pressure in the exhaust and through the engine is recorded by many probes which are connected to U-tubes and gauges. Temperature is measured at all bearings and seals and at many other points in the engine's air path through thermocouples. Engines on a test stand are tested for thrust ratings and fuel consumption for a period of time. Endurance tests at various speeds are also an important part of an engine's test program.



Pratt & Whitney Aircraft

This cutaway view shows the anatomy of the engine. The large front portion contains the fan section. This is followed by the low compressor, the high compressor, the burner, and finally the turbine sections.

For more extensive testing Pratt and Whitney has a special lab named the Willagoos Laboratory where most of the atmospheric conditions an engine will experience can be simulated. Batteries of compressors, exhausters, boilers and coolers make it possible to present air to the engine in almost any form. Huge ducts run from the coolers and compressors to the intakes of the jet and provide air of any temperature from −70° to 350°F at a rate of 300 to 400 lbs. per second. Similarly another duct receives the thrust from the tail and exhausts it, simulating the reduced pressure behind an engine in flight. If desired, the entire engine can be externally subjected to the temperature and pressure it would receive at any altitude.

Testing an engine on a test stand has a particular advantage over testing on a test plane because the engine can be tested at any Mach number at a given altitude condition.

A test plane flying at a given altitude is limited to a small range of speeds in which it can stay at that altitude.

Pratt & Whitney Aircraft

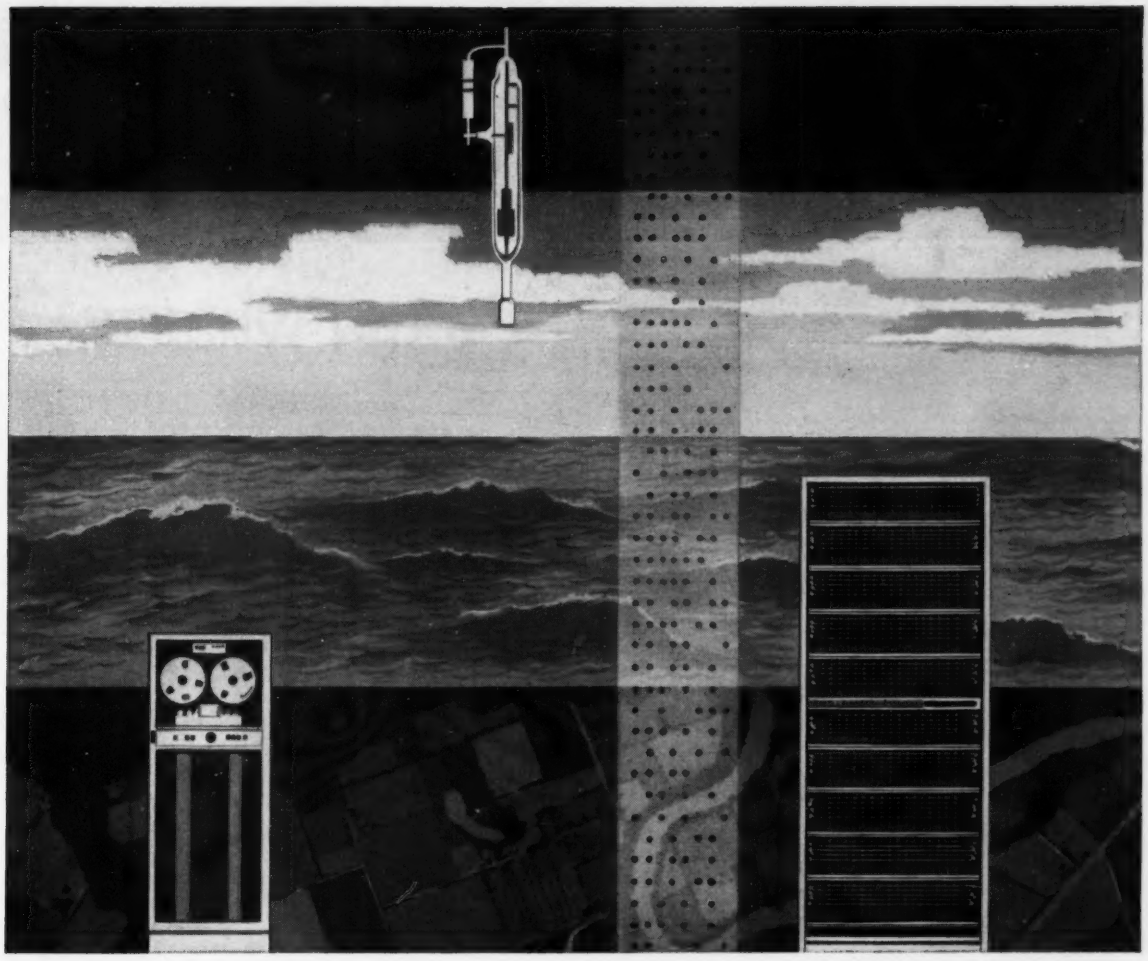
These are only a few of the huge compressors and exhausters required to keep Pratt and Whitney's test stands at the Willagoos lab. supplied with air at almost any required temperature and pressure.

However, flight testing is still an important part of the test program. The hugh compressors and exhausters at the Willagoos lab cannot be rapidly shut down or started up to simulate quick changes in speed, nor can an air start be simulated because of the danger of getting non-ignited fuel into the exhausting system. For these tests, the engine is placed in a pod and hung from the bottom of Pratt and Whitney's huge test plane.

Results from test runs can be transmitted by intercom to the computer center where a key puncher punches the IBM cards as the information is received. These cards are then fed into an already-set up machine which processes all the data and calculates performance within 30 to 45 minutes of the time the test readings were taken. These performance ratings then aid the engineers in further testing the engine.

Test results then go to performance engineers who analyze them and suggest design changes. Usually the first engine tested meets predicted performance rates and further engines go on to surpass these ratings. The first JT-3D engine met its predicted 50% increased thrust and 13% better specific fuel consumption. The latest JT-3D now surpasses both of these ratings by 2%.

Performance data also leads to the development of entirely new engines. On the basis of the success of the JT-3D, Pratt and Whitney is now developing two fan engines, called the JT4D, from its larger J-75 engine. The first of these engines will use the JT-3D fan and will boast 22,500 lbs. thrust, while the second, with a larger fan, will have 25,000 lbs. thrust. Pratt and Whitney is also working on a smaller fan engine for commercial use designated as the JTF-10. The JTF-10, designed for short and intermediate ranges, will power the Douglas DC-9 jet transport.



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Engineers at Pratt & Whitney Aircraft today are concerned with the development of all forms of flight propulsion systems—air breathing, rocket, nuclear and other advanced types for propulsion in space. Many of these systems are so entirely new in concept that their design and development, and allied research programs, require technical personnel not previously associated with the development of aircraft engines. Where the company was once primarily interested in graduates with degrees in mechanical and aeronautical engineering, it now also requires men with degrees in electrical, chemical, and nuclear engineering, and in physics, chemistry, and metallurgy.

Included in a wide range of engineering activities open to technically trained graduates at all levels are these four basic fields:

ANALYTICAL ENGINEERING Men engaged in this activity are concerned with fundamental investigations in the fields of science or engineering related to the conception of new products. They carry out detailed analyses of advanced flight and space systems and interpret results in terms of practical design applications. They provide basic information which is essential in determining the types of systems that have development potential.

DESIGN ENGINEERING The prime requisite here is an active interest in the application of aerodynamics, thermodynamics, stress analysis, and principles of machine design to the creation of new flight propulsion systems. Men engaged in this activity at P&WA establish the specific performance and structural requirements of the new product and design it as a complete working mechanism.

EXPERIMENTAL ENGINEERING Here men supervise and coordinate fabrication, assembly and laboratory testing of experimental apparatus, system components, and development engines. They devise test rigs and laboratory setups, specify instrumentation and direct execution of the actual test programs. Responsibility in this phase of the development program also includes analysis of test data, reporting of results and recommendations for future effort.

MATERIALS ENGINEERING Men active in this field at P&WA investigate metals, alloys and other materials under various environmental conditions to determine their usefulness as applied to advanced flight propulsion systems. They devise material testing methods and design special test equipment. They are also responsible for the determination of new fabrication techniques and causes of failures or manufacturing difficulties.

IT'S LITERALLY ALL AROUND YOU!

The word *space* commonly represents the outer, airless regions of the universe. But there is quite another kind of "space" close at hand, a kind that will always challenge the genius of man.

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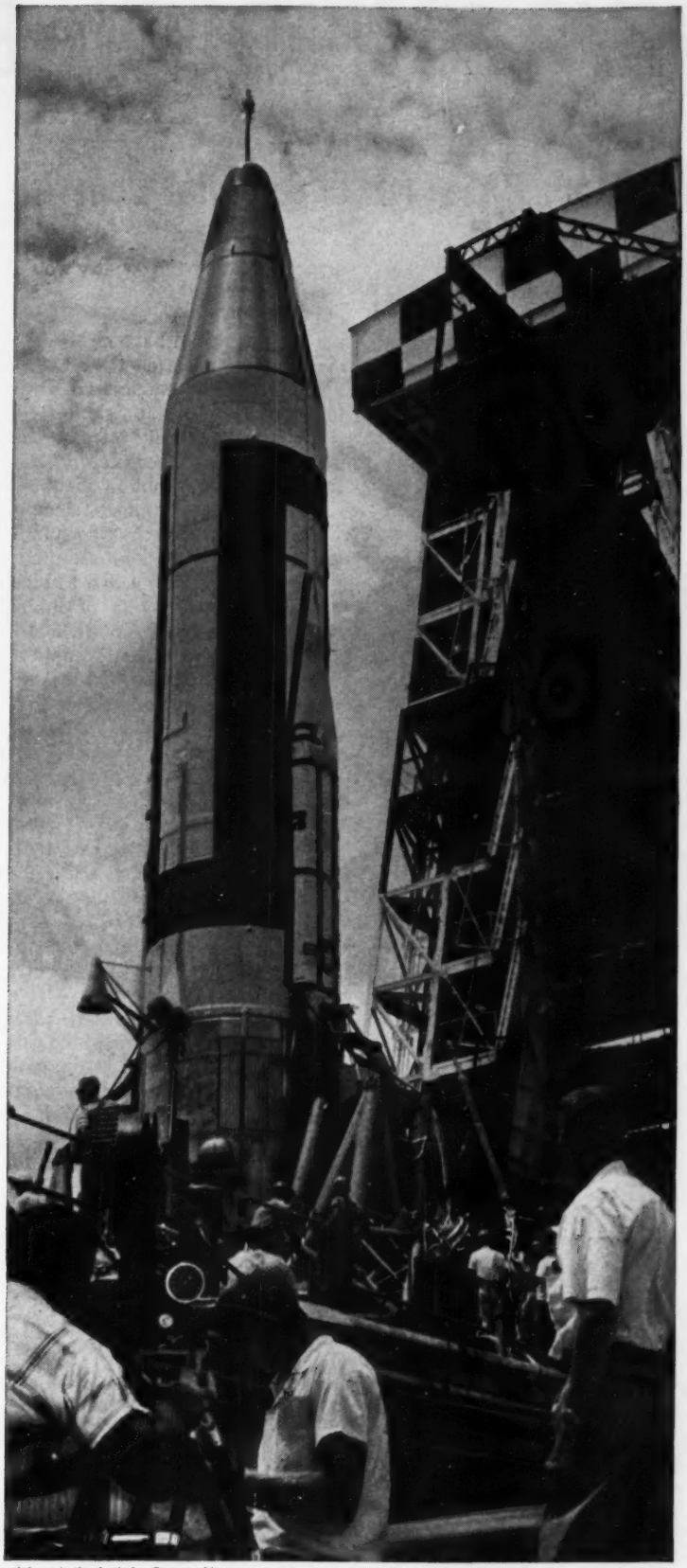


Atlas missile, built by Convair (Astronautics) Division of General Dynamics Corporation as prime contractor.

ANOTHER WAY RCA SERVES DEFENSE THROUGH ELECTRONICS

RCA ELECTRONICS CUTS DOWN THE COUNTDOWN

To our missile experts, "is it ready" is almost as important as "how far can it go." For retaliatory power, missile crews must be able to launch a maximum number of missiles in rapid fire order.

America's intercontinental ballistic missile, the Atlas, had already proved itself for distance on a 5500-nautical-mile range. But checkout and launching took several hours. So the next step in turning the missile into an operational weapon was to make it ready for quick action. RCA was selected to build an electronic system that would radically reduce the countdown time at the Atlas Operational Bases now under construction.

Now, in a matter of *minutes*, this elaborate electronic system can determine if any part needs attention—or signals that the missile will be ready to go.

This automatic checkout equipment and launch control system for the Atlas is one more of the many ways in which RCA Electronics works to strengthen our national defense.

RADIO CORPORATION OF AMERICA

UNIVERSITY ANNOUNCES

Photo Science

Gerald M. Zeitlin, Merion, Pa., a fifth year EE, shows a working model of the 1,000-ft. wide radar designed by the University for construction in Puerto Rico. Mr. Zeitlin built the scale model to plot in advance the signal strength of the radar in any direction at various planes. Work done with this model is saving money for the Department of Defense, which will pay cost of building the world's largest and most powerful radar.

Program Offers Far Reaching Benefits

The new Cornell University Center for Radiophysics and Space Research will be of great value both to the University and to the nation, according to Professor Thomas Gold, director of the Center.

In a recent statement, Professor Gold outlined the basic reasons for university research. "One is to obtain new knowledge, another to show young people how to obtain new knowledge, and the third is to maintain the perspective in the teaching of old problems which comes only with the acquisition of the new. . . . The Cornell University Center for Radiophysics and Space Research is to serve all three purposes."

He stated that work in the field of radiophysics and space research is possible only with the support of government agencies but declared that the work should not be concentrated entirely around these organizations. According to Professor Gold, "If the universities failed to take their share in as important a new field as space research, and it was left entirely to government and commercial organizations, then the country would suffer in the future from the lack of people trained for the work. The universities would have missed the opportunity to enrich their teaching through the acquaintance with this new and dynamic field.

"Without university interest, the government space research organizations will fail to obtain adequate support from the country, since a widespread growth of understanding and interest will be required; the universities are needed to take the lead in the formation of public opinion in the new scientific field.

"With the enthusiastic support the Center has from the strong physics and engineering facilities, I am sure that we will add to the vast fund of knowledge needed before outer space can be conquered," Professor Gold stated. He went on to describe the importance of space research to the field of cosmological theory. He asserted that "the study of the planetary system and particularly the moon will give us much information about the remote past. On the earth the vigorous processes of geology have completely obscured the early stages, whilst on the moon there is undoubtedly a record that goes back a great deal further. Information obtained from future landings on the moon may well allow us to reconstruct the main outline of the formation of the solar system and therefore also of the earth."

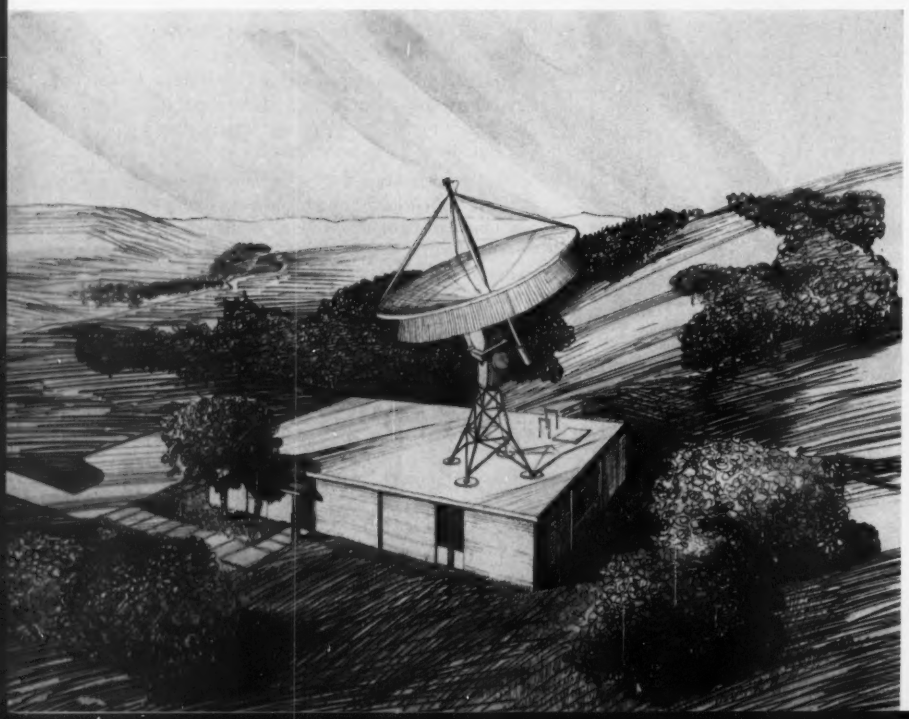


Photo Science

A transmitting station for probing the universe (artist's conception) is one of three new units which the Cornell University Center for Radiophysics and Space Research plans to use in its program. The transmitter dish is 28 ft. in diameter. Construction on a pivot will enable it to send signals to any area of the visible sky.

SPACE RESEARCH CENTER

Engineers, Physicists, Astronomers Join to Probe Universe

The first large university-sponsored center for radiophysics and space research has been launched by Cornell University.

Professor Thomas Gold, at thirty-nine one of the youngest of the world's internationally recognized cosmologists, has been selected director of the Cornell University Center for Radiophysics and Space Research. Professor Henry G. Booker, director of the School of Electrical Engineering and a leading scientist in theoretical research on electromagnetism and radio propagation, will serve as associate director of the Center.

The Center is to have the support of the staffs of the various engineering colleges as well as the departments of physics and astronomy. According to Dean Corson, "The organization of the Center makes it easy to bring together a group of people representing several disciplines. Any problem which arises, whether it is a problem in electrical engineering, physics, astronomy, or aerodynamics, will have the immediate attention of an expert. Furthermore, graduate students trained in this intellectual atmosphere will learn to ignore the barriers between traditional engineering and scientific disciplines. Such a synthesis will be of great advantage in solving the intricate maze of space-age problems."

William E. Gordon, professor of electrical engineering, was largely responsible for the design of a giant radar to be erected soon in Puerto Rico. Thus, the Radiophysics and Space Research Center will have the world's largest and most powerful radar at its disposal. The installation will make it possible to probe millions of miles deeper into outer space than man has ever been able to penetrate before. When in operation, the radar, with a 1,000-ft wide dish and a tripod 600 ft high supporting the feed antenna, will send signals at a power peak of 2.5 megawatts and a frequency near 420 megacycles.

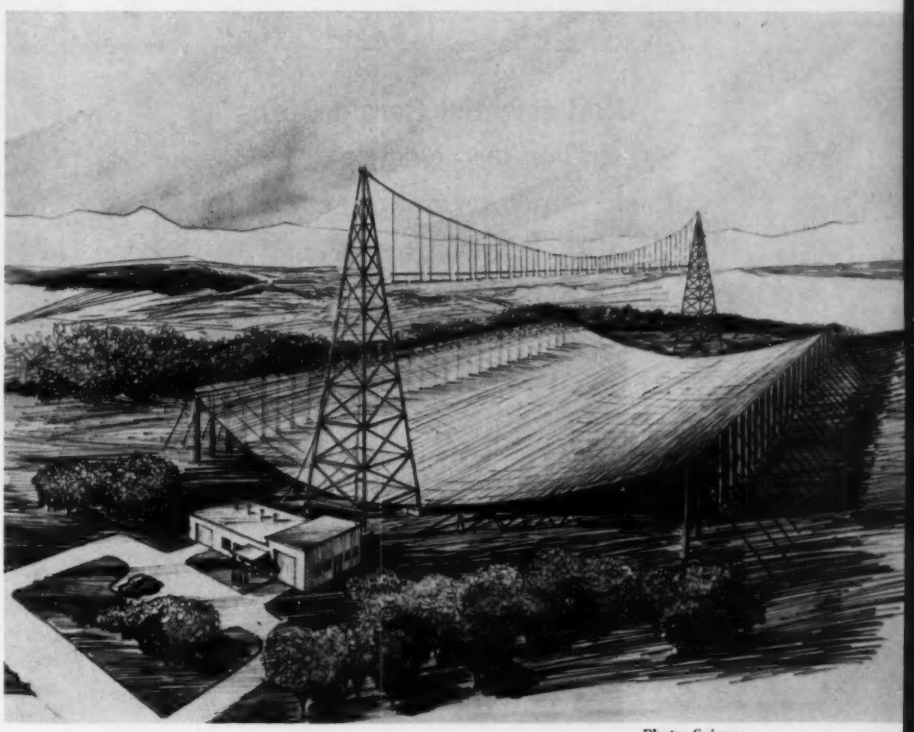


Photo Science

Radio astronomy receiver will feature a 500-ft. long antenna between two towers and will have a reception area of 150,000 sq. ft.

It is hoped that the giant radar will make possible the study of the under-surface of the planet Jupiter, about 400 million miles away when closest to the earth. The current maximum distance that a radar beam has pierced outer space is 30 million miles, a mark that was set by a recent radar contact with Venus.

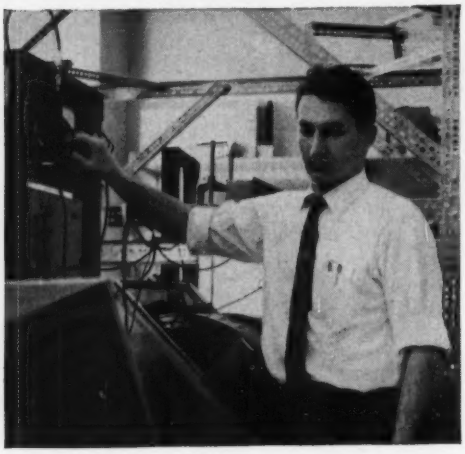
The radar will also be used to study the ionosphere and the transient streams of charged particles from outer space which cause the aurora phenomena.

Because of the size and design of the radar, the motion of the antenna beam is limited to 20 deg in each direction. It will, however, provide access to a number of planets because of its position near the equator, sweeping a band of atmosphere about 40 deg wide. It will be located in a natural bowl of coral limestone, which is porous and will allow for drainage.

In addition to the radar colossus which the Department of Defense is financing for the space research unit, two other new installations that will permit extensive research are scheduled to be constructed on the outskirts of the Cornell campus. These are a radio astronomy receiving apparatus at a suitable location south of Ithaca, and a transmitting station on University property. Both radio astronomy and the possibilities of the use of forward scatter will be studied.

Basic Research at IBM

IBM scientist Gerald Burns studies ferroelectrics to improve understanding of their basic properties.



A basic research project

"I'm using nuclear resonance to explore ferroelectrics," says IBM scientist Gerald Burns. "We're trying to discover how the ions in a ferroelectric crystal are arranged, and why and how they change position and structure with temperature changes. Ferroelectric crystals have a reversible spontaneous polarization . . . that is, they can be polarized in either of two directions, and, by the application of an electric field, polarization can be reversed."

How did Gerry Burns come to work on this problem? "I started this particular research project because it was related to other work I had been doing and I felt it would prove challenging and rewarding. Little is known about what goes on in a ferroelectric crystal—or why. Our basic objectives are to find out *what* and *why*.

"At the planning stage, the project seemed to offer a great research potential, but none of us was sure how long the project might last or what its ramifications might eventually be. It's a good example of the basic research done at IBM."

A day at the laboratory

One of the eight scientists in the Ferroelectric Research Group, 26-year-old Gerald Burns began a recent day by setting up equipment for the first daily run.

"The experiment is conceptually quite simple," he explained. "A ferroelectric crystal is placed in the tank circuit of an oscillator, between the pole pieces of a large electromagnet. The sample is surrounded by a dewar so that the temperature can be accurately regulated. Then the magnetic field is slowly decreased. When the field reaches certain values, the nuclei in the crystal absorb energy from the oscillator. The trick is to detect this absorption which is quite small. Runs at various temperatures are made, and the temperature dependence of this absorption is studied.

After setting up the first run, Gerry Burns met with the head of his group. Together, they discussed the temperature dependence of the nuclear quadrupole resonance coupling constants. Several helpful suggestions were made.

Gerry Burns then talked with chemists who grow the crystals used in the experiments. They discussed possible variations in the crystal-growing method and considered the growth of other crystals in order to broaden the experiments.

Early in the afternoon, he attended a seminar conducted by a visiting professor on the subject of the atomic structure of solids. Each week, several such seminars on a variety of technical matters are given.

After the seminar, Gerry Burns returned to set up another run at a different temperature. He also talked to a technician about building a new piece of equipment to be used in future experiments.

Excellent facilities and programs

"Besides these experiments, I'm also doing some theoretical calculations in the field of nuclear quadrupole resonance. The actual computations were done here at the Laboratory on an IBM 704, which can perform *in minutes* computations which would take weeks if done by other methods.

"This is one of the advantages of working at IBM. Large-scale high-speed computers are available to research scientists when needed. Furthermore you will find your colleagues always willing to help when you are stumped by a problem. Many of these men are recognized authorities in their fields. The exchange is always informative and often stimulates new ideas and approaches.

"Our Company offers many educational opportunities—both in general education and for advanced degrees," Gerry Burns said. "As an example, engineers and scientists may earn a Master's Degree in a post-graduate program conducted by Syracuse University right here in Poughkeepsie.

"We also have a very useful library. Just the other day I dropped in to pick up some technical papers I needed as source material for an article. I've already published one paper on my experiments," he noted. "You're encouraged to publish your findings and to participate in professional society meetings. It's important for a research man to work in an atmosphere where independent thinking is encouraged and where every effort is made to facilitate research investigations."

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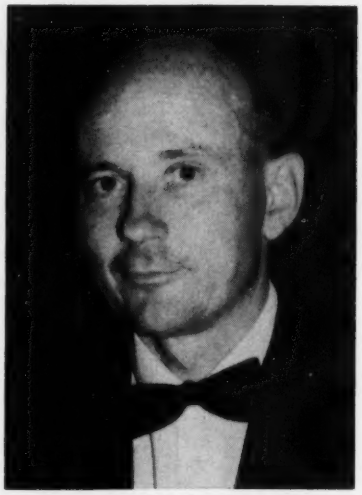


S. D. Teetor

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationship between the College and its alumni."

THE PRESIDENT'S LETTER—

Over the weekend of October 3, 1959, a step forward was undertaken by the Society. A meeting was held, in Ithaca, with the Executive Committee in attendance. The meeting consisted of the Regional Officers as well as the National Officers.

The basic purposes of the meeting were as follows:

1. To improve the overall liaison with the College of Engineering personnel.
2. Determine what steps should be taken to increase the number of Regional Chapters of the Society.
3. Determine what additional steps the Society could take, so as to be of more benefit to the College.
4. Ascertain what functions of the Society should be handled on a National level and on a Regional level.
5. Determine the best use of the Cornell Society page in this magazine.

In a later issue of the magazine, complete details of the recommendations of the Executive Committee and the final action taken on the same, by the membership, will be reported.

Following is a message of special importance to the graduate members of the Society: The total membership to date this year is 1900. This is a good start, and higher than the number this time last year, but the "long pull" has only begun. At the end of last year the membership was 3383. This year we have set a target of a minimum of 4,000 members. The ratio of 4,000 members to the 18,000 Cornellians eligible, is higher than the average membership rate for most Societies, but considering the College concerned, we do not feel that it is impossible to reach the target set for this year. Therefore, if you have not sent in your Membership card and dues, please do so at once.

As mentioned above, the Society is interested in forming additional regional chapters. Any groups of Cornell Engineers that are interested in starting a branch chapter and are in need of support or advice from the National Group, are urged to contact me at the earliest possible time. As a rule-of-thumb, it is felt that any area that has 75 Cornell Engineers within a radius of 75 miles, has sufficient potential for the forming of a branch Chapter. The Society Officers feel that a larger number of branches will be to the mutual benefit of the University; Engineering College; the Undergraduates and the Graduates, and therefore every reader of this message is requested to do his part to help form a new chapter or to become a more active member in the Chapter within his residential area.

The question of having a Cornell Society of Engineers luncheon or dinner meeting at the same time and place that National Conventions of the Parent Societies, such as the A.S.C.E.; A.S.M.E.; etc. are held, was discussed at our meeting on the 3rd of October. Inasmuch as many other Colleges do have college meetings during these aforementioned Society conventions, it has been decided that the Cornell Society will take steps to do the same, as far as may be practical. Any members of the Society that may be in a position to take an active part in these types of meetings are requested to contact the Society. The basic paper work of scheduling and setting up these meetings could be handled by the staff of the Society and the only responsibility that would be placed on the member interested in organizing the same, would be the handling of the meeting at the time of the actual convention. Arrangements could be made so that a Regional or National Officer of the Cornell Society could attend the meeting, if it was deemed desirable.

The basis of any Society's growth is good ideas. With this in mind let us all endeavor to direct our thoughts about the Society and its affairs along the proper channels to where they will do the most good. Thank you all for your assistance in this matter.

STEPHEN D. TEETOR, C.E. '43

ALUMNI ENGINEERS

Edited by
J. F. Thomas, EP '63

Rollin H. McCarthy, A.B. '21, M.E. '22, M.M.E. '25, has been named a fellow of the American Society of Mechanical Engineers. This is the highest level of attainment in ASME, restricted to persons with twenty-five years' experience in engineering who are outstanding authorities in their fields. There are about 400 fellows among the 50,000 members of the society. Mr. McCarthy is also a member of the Cornell Society of Engineers.

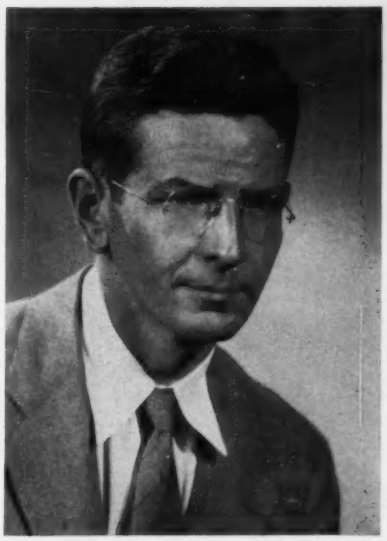
Robert W. DeBengam, M.E. '50, has joined the Trane Co. sales office in New York as a sales engineer. Mr. DeBengam recently completed the specialized engineering program for graduate engineers at Trane in La Crosse, Wisconsin. He is a lieutenant commander and executive officer in the organized Naval Air Reserve.

The Trane Company is a leading manufacturer of heating, air conditioning, ventilating and heat transfer equipment with home offices in La Crosse.

Bradford R. Howes, B.M.E. '58, has been assigned as a sales engineer to the Trane Company sales office in Philadelphia. Mr. Howes completed the Trane specialized engineering program in La Crosse, Wisconsin prior to receiving his field assignment. The year-around postgraduate program is designed to bridge the gap between scholastic background and assignment in the field. The Trane Co. is a major manufacturer of air conditioning, heating, ventilating, and heat transfer equipment.

Bradford R. Howes

Harold M. Alexander, B.Arch. '34, recently became vice-president of technical services for Libby-Owen-Ford Glass Co., Toledo, Ohio. With the company since 1934, he has held such positions as director of development, general manager of research and development, assistant to the vice-president of sales and assistant to the executive vice-president. During World War II, he headed precision glass sales and service for the Armed Forces.



Alumni News

Harold M. Alexander

Louis J. Cutrona, A.B. '36, professor of electrical engineering at the University of Michigan, was appointed a research engineer to serve as head of the Willow Run Radar Laboratory. Professor Cutrona received the Ph.D. in physics at the University of Illinois in 1940 and in his new position will become head of the largest laboratories within Willow Run, one of Detroit's main airports. He will be involved in major programs in the field of airborne and ground-based radars.

Merritt Harrison, B.Arch. '11, recently received one of the highest awards that can be bestowed by his profession. He is called the dean of architects in Indiana by

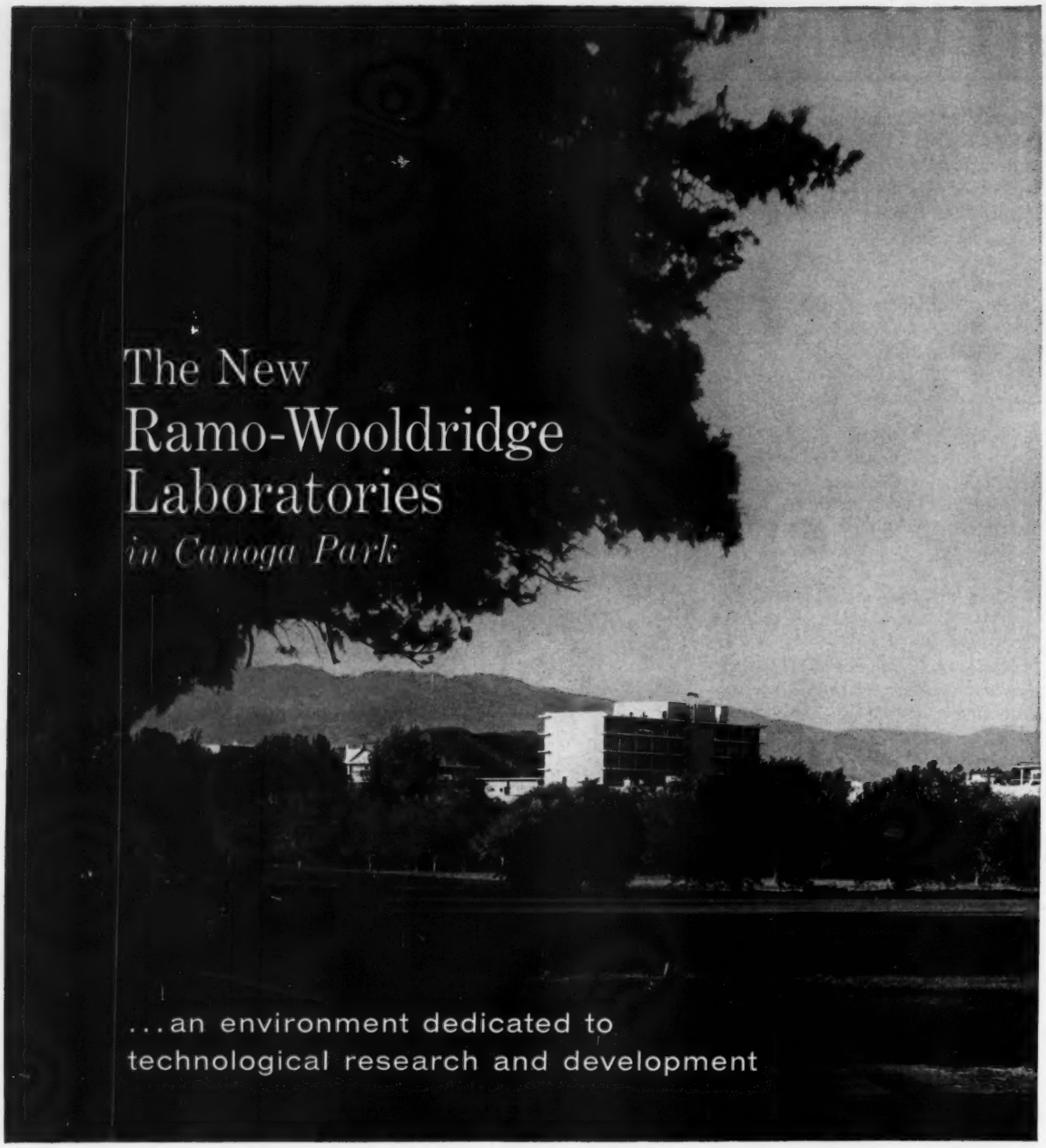
Alumni News

Merritt Harrison

fellow designers and was made a fellow in the American Institute of Architects at the Institute's convention in New Orleans. In this honor, Mr. Harrison joins his brother, William H. Harrison, B.Arch. '21. Mr. Harrison has designed many churches, most recently Meridan Street Methodist Church, Indianapolis. Earlier in his career, he designed the coliseum at the state fairgrounds and says it is one of his favorites among the many buildings he designed. His philosophy is as simple as his workroom; form always follows function. "A building has to serve a function first," he says. "Beauty then comes through proper design in proportion as well as in color and style."

Elliott J. Siff, B.M.E. '51, has joined Kearfott Co., Little Falls, New Jersey, as senior engineer in the preliminary design section. Mr. Elliott, who received a Master's Degree at Columbia in 1957, previously worked for Sperry Gyroscope and United Aircraft.

John C. Gibb, M.E. '24, reports that now, for several years past, and for the immediate foreseeable future, he will be engaged in travelling for the Socony Vacuum Oil Co. as senior engineer representative concerned with the lubrication of gas and diesel engines.



The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

For specific information on current openings write to Mr. D. L. Pyke.

THE RAMO-WOOLDRIDGE LABORATORIES

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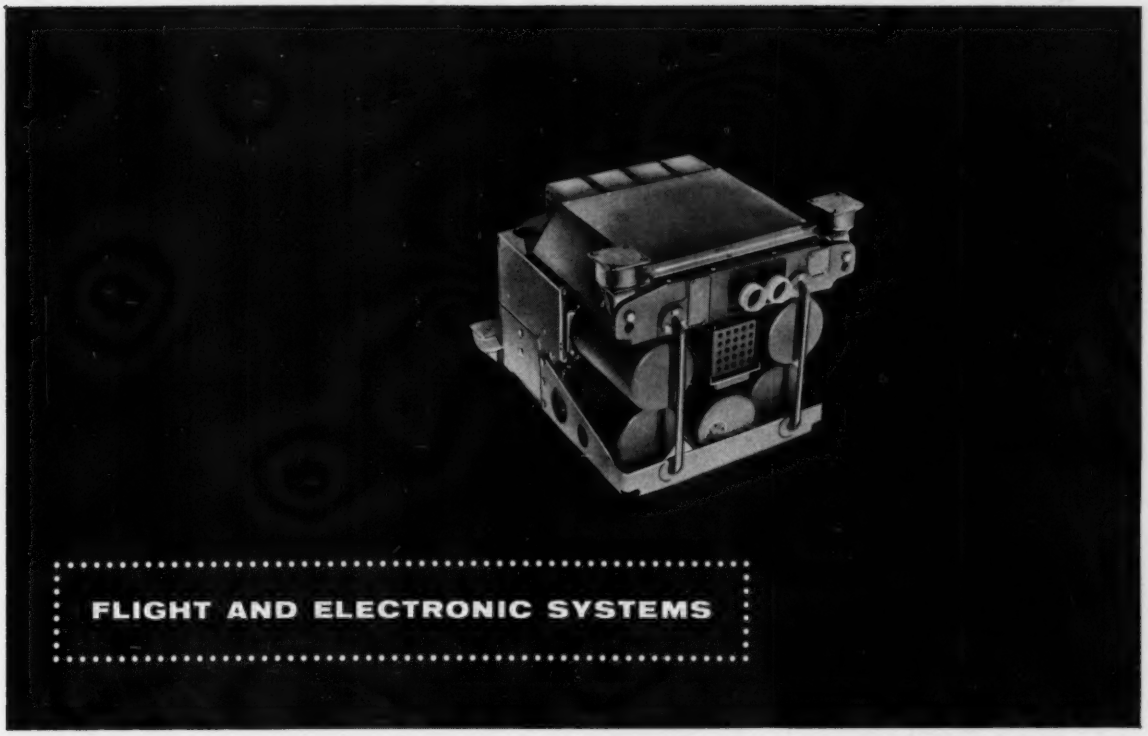

• Flight data systems are essential equipment for all modern, high speed aircraft. In the AiResearch centralized system, environmental facts are fed to a central analog computer (above), which in turn indicates to the pilot where the aircraft is, how it is performing, and makes automatic control adjustments. Pioneer in this and other flight and electronic systems, AiResearch is also working with highly sensitive temperature controls for jet aircraft, autopilot systems, submarine instrumentation, transistorized amplifiers and servo controls for missile application, and ion and radiation measuring devices.

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OUR FIRST COURSE IN ELECTRICAL SCIENCE

by Professor N. DeClaris

Present-day scientific and technological advances have created serious impacts on engineering education. To provide adequate training and development of a young electrical engineer, an undergraduate curriculum is needed that will produce not narrow specialists with "practical" skills, but rather sound-thinking individuals capable of coping with constantly changing modes of thought and practice.

This educational philosophy is reflected in the approach and mechanics of the first course in the School of Electrical Engineering at Cornell University. The course is based on the text, *An Introduction to Electrical Science* by Professor H. G. Booker, recently published by McGraw-Hill Book Co. The aim of the course is to employ mathematics as an orderly process of thought for presentation of the subject matter. In the development of the fundamentals, the physical interpretation is interwoven with the mathematics, line by line.

There is a unique pedagogical feature in this course that departs significantly from conventional practices. Traditionally, electrical engineering is based, in a broad sense, on two approaches: i) circuit theory, and ii) field theory.

Circuit theory is based on models for physical behavior and devices which emphasize time considerations. On the other hand, field theory commences with the actual (and often more complex) situation in which both time and space considerations are given equal emphasis.

It is a customary practice in our universities to acquaint the students with the first and the second approach (in most cases in that order) by means of a sequence of courses during their first two years (sophomore and junior) in electrical engineering. It is evident, however, that the methods and tools of both circuit theory and field theory are based on the same physical laws. While a student is taught both of these valuable techniques for coping with physical problems as separate spheres of activity, the task of examining and "discovering" the common physical principles on which these processes of thought are based is ordinarily left up to the student. This is by no means an easy task. In fact, such attempts are often un-

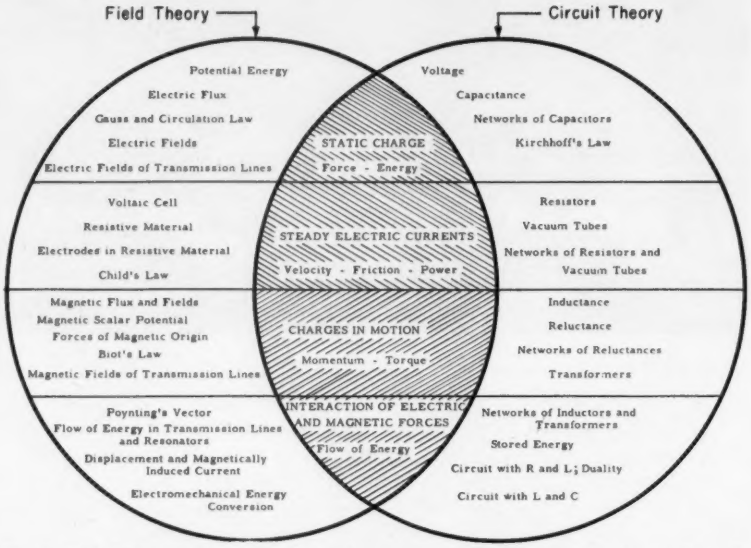
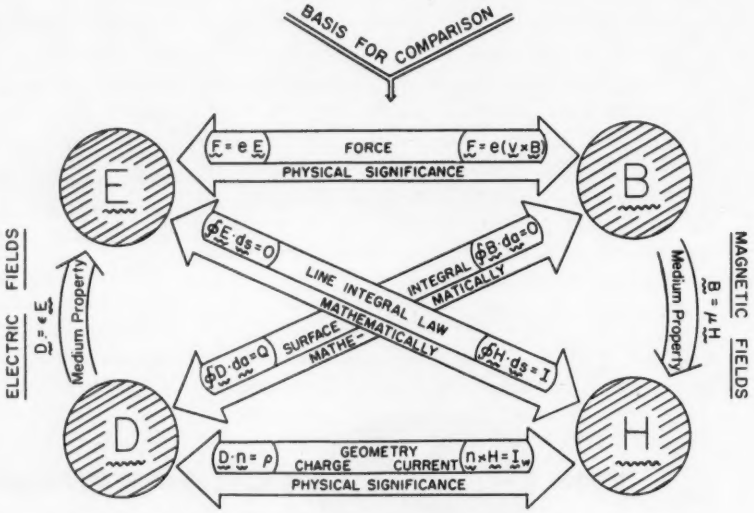


Fig. 1: This is the outline of the beginning course in electrical engineering at Cornell. The white portions represent the spheres of circuit theory and field theory. Both of these processes of thought are based on the same physical laws (common shaded area).



COMPARISON OF ELECTRIC AND MAGNETIC FIELDS

Fig. 2: The diagram illustrates how an appreciation of the two spheres of thought can be acquired. The flux and field strength vectors may be compared either on the basis of their physical meanings or on the basis of their mathematical relationships.

successful, and if unguided, they may lead to serious misunderstandings.

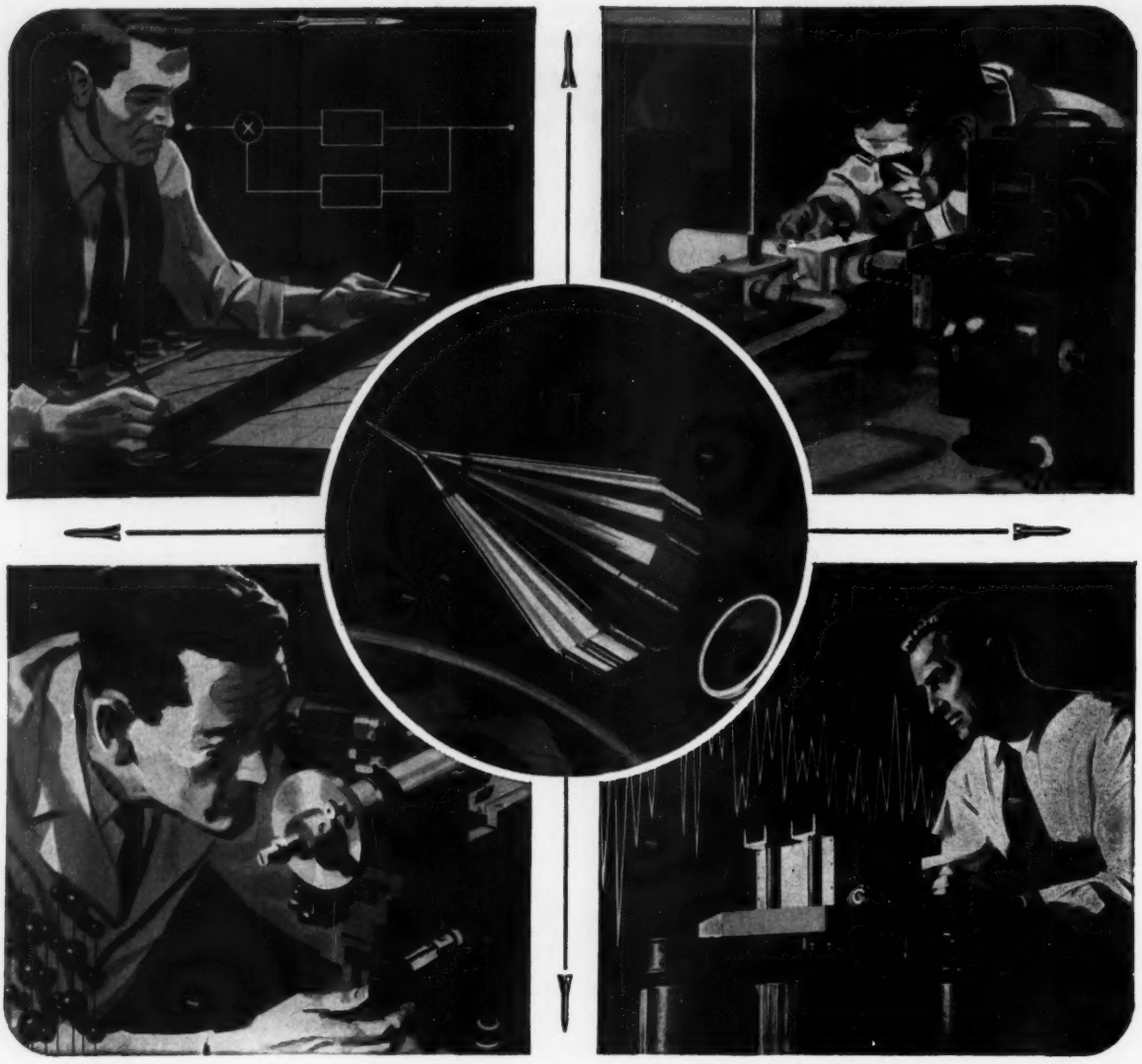
Professor Booker has based his text on exactly this issue. A physical principle is presented and its applications to both circuit and field theory are exploited simultaneously. A chart of the content of the course and the sequence of its presentation is shown in Figure 1. It represents two academic terms of work. Each term is also divided into two parts (horizontal lines), each dealing with one specific topic of electric charge behavior. The course begins at the top of the shaded portion of the figure and it unfolds horizontally to present the unshaded segments of both spheres. A specific example illustrating the way that the course attempts to create an appreciation for the process of thought is shown in Figure 2.

The organization of the course and the presentation of the material through lectures and tutorial sessions are intended to develop the ability of the student to understand and express concepts with words as well as to apply them for solving problems. These two aspects of education are being equally emphasized in homework and are being evaluated in examinations by especially designed exercises. Finally, an attempt is also made to challenge each student's maximum ability and to give recognition for favorable attitude towards study and for work beyond a specified minimum.

About the Author

Professor De Claris received the Bachelor of Science degree from A. and M. College of Texas and the degree of Doctor of Science from the Massachusetts Institute of Technology. He joined the faculty of Cornell University in 1956 where he is an associate professor of electrical engineering. At Cornell University, in addition to teaching, he also heads a research group on network theory.

Dr. De Claris has acted as a consultant to several industrial firms. He is the author of numerous technical papers and a member of a number of honorary and professional societies. Since 1958 he has been an associate editor of the I.R.E. Transactions, Professional Group on Circuit Theory.



YOUR TASK FOR THE FUTURE

Since its inception nearly 23 years ago, the Jet Propulsion Laboratory has given the free world its first tactical guided missile system, its first earth satellite, and its first lunar probe.

In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space; hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, *Director, JPL*

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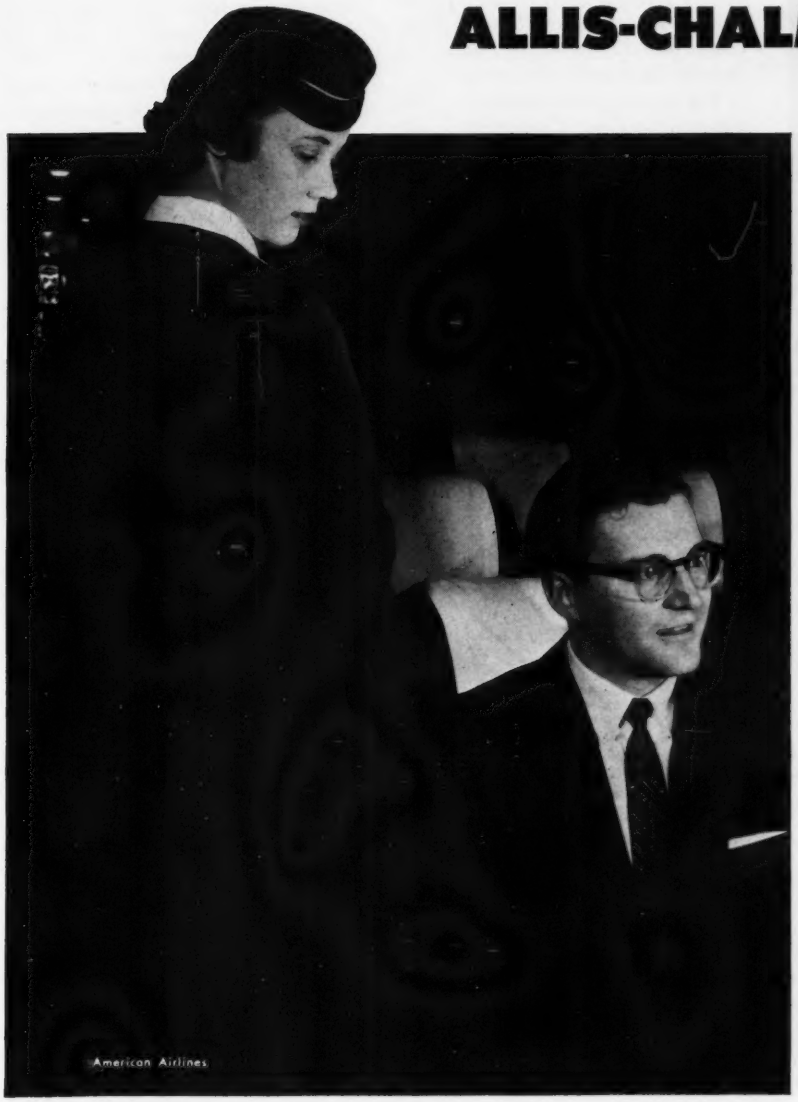

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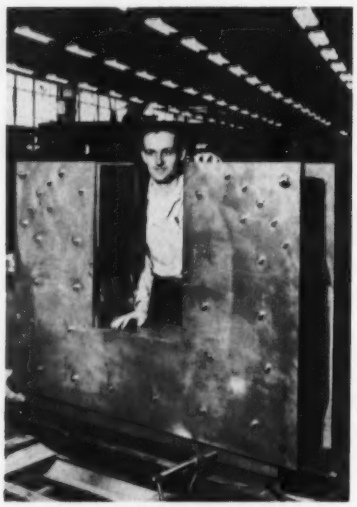
TECHNIBRIEFS

Edited by D. J. Martin, ME '62

WORLD'S LARGEST PERMANENT MAGNET USED IN REACTOR

The world's largest permanent magnet is to be used to pump liquid sodium in a nuclear reactor.



Allegheny Ludlum Steel Corp.

A workman at the Arnold Engineering Company plant is shown with the world's largest permanent magnet. This single permanent magnet weighs 1720 pounds, and will be used to pump liquid sodium for the breeder reactor at the Argonne National Laboratory for the Atomic Energy Commission.

The breeder reactor is to be operated by Argonne National Laboratory for the Atomic Energy Commission. It will be located at the National Reactor Testing Station near Idaho Falls, Idaho.

The 1720-lb magnet was made by the Arnold Engineering Company, a subsidiary of Allegheny Ludlum Steel Corporation. The flux density at the center of the 16½-in. gap of the huge magnet is 1100 gausses. About 50,000 ampere-turns was needed to magnetize the unit.

It is customary to use an electromagnet in pumping the liquid sodium in this atomic application, but in this instance a large permanent magnet must be used because the magnet will be completely surrounded by the liquid metal.

The pumps operate without moving parts. A current passing through the sodium at right angles to a strong magnetic field produces a force on the sodium itself. Thus the magnet acts as a pump and the sodium is circulated through a closed piping system.

SILICON CARBIDE SURFACES FOUND TO EMIT ELECTRONS

Electronic tubes of the future may be "transistorized," according to Westinghouse Electric Corporation scientists, if practical use can be made of an effect recently discovered. It has been found possible to obtain a constant flow of electrons directly out of the surface of certain semiconductor materials.

The latest semiconductor to yield this unique flow of electrons is silicon carbide, a hard, crystalline solid best known for its widespread use in impure form as an abrasive in grinding wheels. Westinghouse scientists have found that the electron flow or "emission" is comparable to that of the average electronic tube.

The escape of electrons from silicon carbide accompanies the emission of visible light from the crystal. This visible light is a form of electroluminescence and occurs when enough voltage is applied across the junction to cause loss of the junction's normal electrical resistance.

When this loss of resistance occurs, small blue spots of light appear in the crystal in the region of the junction. Electrons escape from these bright, light-emitting spots, especially from those located nearest the surface of the crystal.

In an ordinary vacuum tube, considerable power is wasted in keeping the filament at a constant high temperature. A semiconductor crystal could perform the same task consuming only a negligible amount of power.

METEOR TRAILS USED IN COMMUNICATION SYSTEM

An experimental radio communication system that uses meteor trails for two-way message transmission has been developed by the National Bureau of Standards Boulder, Colorado Laboratories under the sponsorship of the Air Force Cambridge Research Center. With this system, messages have been sent at speeds up to 4800 words a minute, eighty times the present speed of transmission by teletype.

Early studies indicate that intermittent meteor-burst communication can compete effectively with other long-distance systems, and that it is relatively free from ionospheric disturbances which affect long-distance communication in the high frequency range.

Millions of tiny meteors enter the earth's atmosphere every day, only to burn up before they can fall to the ground. When a meteor reaches the lower part of the ionosphere, the heat due to air friction vaporizes some of the meteoric material, creating a trail of electrons and ionized atoms about 15 miles long behind the meteor. As this trail reflects radio waves, it causes temporary enhancement of radio signals.

Because of the transient nature of meteor trails, they cannot be used continuously to transmit radio signals. Thus a communication system using this phenomenon requires a new approach to message handling and control. The system must operate intermittently at very high speed, and must go into operation automatically when a suitable meteor trail is available for signal enhancement. Obviously there must be some provision for storing messages during periods when no suitable meteor trail is available.

In the Bureau's system, two magnetic tape recorders handle the storage of incoming and outgoing messages at each transmitting-receiving station. Normal teletype messages to be transmitted are first recorded on magnetic tape and then sent at high speed. Received messages are recorded on magnetic tape at high speed and then printed at normal speed.

The system's control equipment determines when conditions are acceptable for transmission of messages. This decision is based on (1) the amplitude-time characteristics of the received signal, (2) the modulation of the received signal, (3) the availability of storage space for incoming messages, and (4) the availability of messages for transmission.

With both transmitters on the air, the system can detect the presence of a suitably located meteor trail within a few thousandths of a second. When either station "hears" a signal reflected by a meteor trail, it shifts its transmitting frequency, thus indicating to the other station its readiness to transmit messages.

At the end of a meteor burst, signal fading or obvious error in received messages causes the system to stop transmitting, and the transmitters return to their original frequency. Under normal conditions, the commands to start and stop and associated events are so timed that no messages are lost.

84-IN. MIRROR TO BE USED AT ARIZONA OBSERVATORY

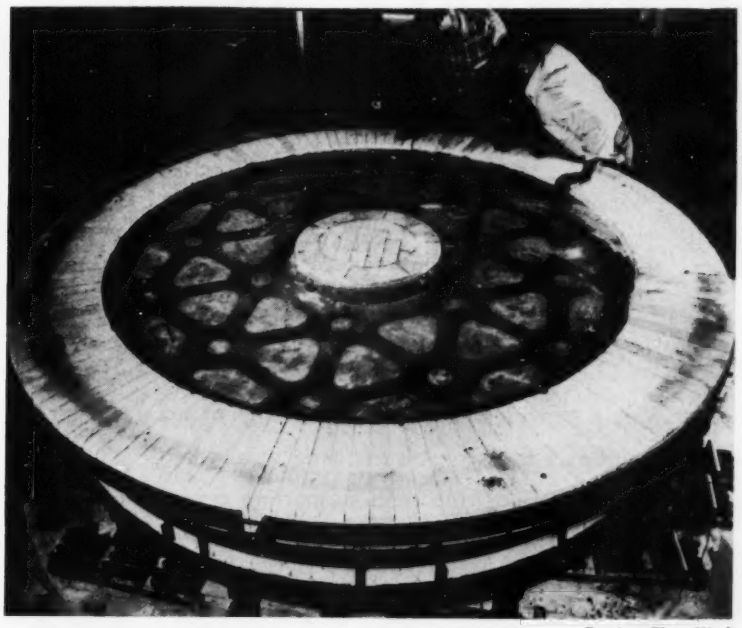
An 84-in. telescope mirror blank for the new Kitt Peak National Observatory, under construction 40 miles southwest of Tucson, Arizona, has been completed by Corning Glass Works.

The 84-in. disk is the biggest piece of glass ever produced by placing solid chunks of glass on a mold and sagging them into a single piece under intense heat. Nine pieces of glass, weighing up to 2,976 lb, were melted down to form the disk. The completed mirror blank is 13 in. thick and has a center hole of 26 in. diameter.

This huge piece of glass was recently removed from an annealing oven at one of Corning's melting plants in which it had been cooled slowly over a seven-month period.

The blank is made of borosilicate glass, which was selected because of its low expansion, thermal resistance, and mechanical strength. It is of ribbed construction on the back face. This honeycombed pattern reduced weight while retaining necessary strength and rigidity. The pattern was formed by use of ceramic cores bolted and cemented into the floor of the brick mold.

The observatory atop 6,895-ft Kitt Peak will go into full operation in about three years. This installation and the National Radio Astronomy Observatory at Green Bank, West Virginia, are the first two observatories in the United States available for the use of all qualified astronomers. Supported by the National Science Foundation with federal funds, the observatories are designed to supplement existing facilities for research in astronomy.



Corning Glass Works

This giant telescope mirror blank, 84 in. in diameter and weighing almost 4,000 lbs., is being readied for shipment to Tucson, Arizona, where it will be ground and polished. The mirror will eventually be mounted in the telescope at Kitt Peak National Observatory near Tucson.

SPECIAL COMPUTER ANALYSES WEATHER BUREAU CLOUD DATA

The National Bureau of Standards has developed a special-purpose computer for the Weather Bureau to analyze data received from a ceilometer, or cloud height indicator. On command, this small-scale data processor will tell an operator not only the current cloud height, but also what the highest, lowest, or predominant cloud height was at any time in the preceding ten minutes.

Cloud height is obtained by means of a device known as a ceilometer that can measure from the ground up to about 10,000 ft. A light beam from a searchlight is reflected by the clouds and is received by a photocell placed at a known horizontal distance from the searchlight. Either the light or the photocell is rotated through an angle of 90 degrees. The cloud height is calculated by simple triangulation, using the angle at which the reflection from the cloud is received and the known baseline. The light source is modulated by a rotation shutter, and the photocell operates in conjunction with a filter and a tuned amplifier to discriminate against ambient light.

Ceilometer indications are observed by an operator who interprets a cathode-ray display and obtains by manual computation answers to a variety of questions. Typical questions might be: At what height did most of the clouds occur over the past ten minutes (or one minute)? What was the lowest level at which a significant number of clouds occurred? The cloud height data analyzer automatically finds the answers to these questions, thereby releasing the operator for more important duties.

To do this, the cloud height data analyzer samples the ceilometer output and records the height at which the greatest signal is received during each span. These data, which represent the most recent ten minutes of information,

are stored in a small 100-word magnetic drum memory. After each scanning of the clouds there is a short period of time during which no information is being received; during this time the stored data are analyzed. The output of the equipment is a set of answers pertaining to the last ten minutes, updated each scan.

NEW THERMOELECTRIC DEVICE AIR-CONDITIONS SUIT

The fighting man of the future may be individually air-conditioned. Placed inside a protective garment, a miniature air conditioner would create an artificial environment, keeping him dry and comfortable at temperatures from the below-zero cold of the Far North to the searing heat of the tropics.

The air conditioner will use thermoelectric cooling which is accomplished simply by passing an electric current through small elements of a solid semiconductor material. By reversing the current, the thermoelectric materials will heat instead of cool. Thus, the air inside the suit can be maintained at any desired temperature automatically.

The complete air conditioner, under development by Westinghouse, will consist of three main components. Thermoelectric units will cool and heat the suit, a lightweight battery will supply the power, and a blower system will circulate the air inside the suit. The air conditioner will be designed to maintain the temperature in the suit at comfortable levels, roughly equal to that normally encountered on a warm, pleasant summer day, while the suit is being worn in temperatures ranging from −40 to 135 F.

MICRO-MODULES REDUCE RADIO TO SUGAR-LUMP SIZE

Rapid progress in a completely new concept in shrinking electronic equipment and products is being made by the Department of the Army. The work has already produced radios as small as sugar lumps and promises a tenfold reduction in size and weight of many vital military devices.

By using tiny micro-modules as circuit building-blocks, electronic miniaturists already have achieved ten-to-one size reductions over today's most refined equipment using printed wiring, transistors, and other small parts.

Small size, highly important in itself for military and other purposes is but one merit of micro-modules. Since the program was launched, tests carried out by RCA and the U.S. Army Signal Corps show that the tiny cubes promise to be highly dependable, have long lives, use little power, deliver high performance, and greatly simplify repairs. They are extremely rugged due to their simplicity and shape.

The smallest units of a micro-module are tiny flakes of conducting, semi-conducting, or insulating materials about .01 in. thick and .3 in. square. Added materials and controlled processing of the wafers turn them into micro-elements with the ability to do the jobs of specific components such as resistors, transistors, capacitors, diodes, inductors, or crystals. Some of the micro-elements do the work of several conventional parts since combinations can be included in one element.

SIX PERTINENT QUESTIONS TO ASK THE ALCOA RECRUITER WHEN HE VISITS CORNELL

Here's What You May Want to Ask About Opportunities at Alcoa

1. Where can I go in Alcoa with my type of degree?
2. In what part of the country would I be located?
3. What kinds of training programs will I participate in at Alcoa?
4. What are my starting salary prospects?
5. Will Alcoa pay my moving expenses?
6. What are my chances for advancement with Alcoa?

And Here's What We Answer:

1. There are openings at Alcoa each year for graduates with many types of degrees. Graduates in mechanical, metallurgical, electrical, industrial, chemical and civil engineering have a wide choice of opportunities in engineering, production, research, development or sales engineering. There also are openings for chemists for research and for business administration and liberal arts graduates in accounting and sales.

2. Geographical location will depend on your field. New engineering, production and accounting employees are assigned to one of 30 Alcoa operating locations throughout the nation. New sales engineering and sales administration employees, after completing a six-month training program, go to one of Alcoa's 72 sales offices. If your field is sales development or process development, you will be located in New Kensington, Pa., or Cleveland, Ohio. Main research laboratories are located in New Kensington, with branches in Cleveland, East St. Louis, Ill., Massena, N. Y., and Chicago.

3. Alcoa has a training program for each new employee. Engineering and production training involves orientation and rotation of assignments for approximately one year. Sales training is conducted in sales offices and in nine plant locations over a six-month period. Accounting training calls for rotation of assignments for 18 to 24 months.

4. Alcoa's starting salaries are competitive with those of other companies. An initial salary is established for a basic four-year degree. Additional credit is given for outstanding personal qualifications, advanced educational training, military service and previous work experience. Future salary progress is based on your own performance and growth potential.

5. Alcoa pays transportation and moving expenses for you and your family. This applies to your first and all subsequent assignments.

6. Alcoa personnel policies assure individual recognition for you. They include regular performance appraisals, individual opportunity for advanced management training, confidential and individual salary consideration and promotion entirely from within the company.

If you'd like to find out more about employment opportunities with Alcoa, contact your placement officer to arrange a campus interview. Mutual interest will result in further interviews at an Alcoa location. For more details immediately, write Manager, College Recruitment, 810 Alcoa Building, Pittsburgh 19, Pa., for the new booklet, *A Career for You With Alcoa.*

Your Guide to the Best in Aluminum Value

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

COLLEGE NEWS

Edited by R. A. Stern, EE '63

Photo Science

In a recent talk before the Cornell University Council, Dean Dale R. Corson emphasized the need for higher salaries for engineering professors.

CORSON STRESSES ENGINEERING TEACHING IN COUNCIL TALK

The fall-off in the number of young people now entering engineering schools was blamed on "Sputnik fever" by Dean Dale R. Corson of the Cornell University College of Engineering. "Sputnik fever," he said, has driven many potential engineers to study science instead of engineering.

Addressing the Cornell University Council on the problems that face engineering educators today, he said: "In the fall of 1958, freshman engineering enrollments were down 11 per cent on the average all over the country. This year, the number of applications was down again. . . ."

He pointed out that attracting the best people into teaching engineering is becoming an increasingly thorny problem. Competition is severe and Cornell, like other universities, finds it difficult to compete with the high salaries offered by industry to promising young engineering graduates.

"Our average undergraduate started at more than $6,000 last year, and it is not uncommon for a Ph.D. engineering graduate to begin working for industry at $12,000 a year," Dean Corson said.

"Furthermore, many of the big companies operate engineering and science laboratories with academic atmospheres so that the young graduate not only finds high salaries in industry, but finds the ivy on the walls as well," he added.

"This competition for staff also extends to older engineers and scientists . . . Some of the West Coast aircraft and missiles companies have staffed their research and development laboratories to a considerable extent with former university professors."

"We can no longer include the view from the Library Slope in a man's salary and tell him it is worth $1,000 a year. The universities which are going to remain strong are those which simply will not be outbid," he declared.

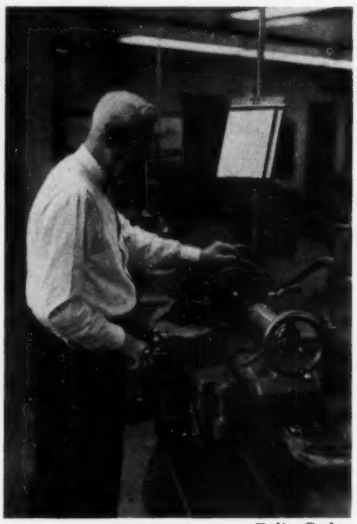
NEW PROFESSOR JOINS E.E. SCHOOL STAFF

Assistant Professor Paul R. McIsaac, who will instruct in the field of microwaves, has a long background in both research and practical experience. Studying at Cornell from 1943–44 and 1946–49, he obtained his B.E.E. with a major in communications and graduated valedictorian. He then did graduate work at the University of Michigan, where he got his Master's Degree, also in communications. Following this, he was awarded a Rotary Foundation Fellowship and attended the University of Leeds in England, where, working under the chairman of the physics department, he did research on high frequency ferromagnetic effects in metals. Professor McIsaac then returned to the University of Michigan, where he held a National Science Foundation Fellowship and completed his doctorate thesis on ferromagnetic effects.

Photo Science

Assistant Professor Paul R. McIsaac, who recently joined the staff of the School of Electrical Engineering, is to teach in the field of microwave technology.

Professor McIsaac has had considerable teaching experience, both in the Navy during World War II as an instructor and also at Cornell during 1949. His practical experience includes work and research at Western Electric, Brookhaven National Laboratory, and at Sperry Gyroscope, where he led the work on microwave tube circuits. He is a member of Eta Kappa Nu, Tau Beta Pi, Sigma Xi and the Institute of Radio Engineers.



Delia Corkey

John Huson, instructor-technician in the materials processing department, will retire at the end of this term after thirteen years at the University.

MATERIALS PROCESSING INSTRUCTORS RETIRE

This academic year marks the retirement of two well-known instructor-technicians in the materials processing department. John Crissey, who retired as of last July, and John Huson, who will retire at the end of this semester, joined the Cornell staff in 1953 and 1946 re-

Photo Science

Assistant Professor Howard N. McManus of the department of thermal engineering recently developed a formula to describe the distribution of fuel in a rocket nozzle.

spectively. Both had wide industrial experience, having advanced to the status of supervisory mechanicians. Both also had prior experience teaching machine shop in high schools and in the emergency education programs during World War II. They will be especially remembered by their students in the freshman engineering machine tools course.

CORNELL HIGH VOLTAGE LAB TO CONDUCT CABLE TEST

The Cornell High Voltage Laboratory, headed by Professor Joseph L. Rosson, associate professor of electrical engineering is undertaking a project of testing high voltage underground power cable, in co-operation with a group of power companies and cable manufacturers. The cables to be tested are new developments of four major cable producers. They are designed to operate in the 350–500 kv range.

The need for high voltage underground cables has developed because of increased power needs in congested metropolitan areas. It has long been known that the most efficient way to increase the power capacity of transmission lines is to increase the voltage rather than the current. This principle is used in overhead lines, many miles of which operate in the 350 kv range. The further use of overhead lines in metropolitan areas, however, is limited by considerations of space and appearance. In addition, overhead lines are hard to maintain and are subject to interruptions due to lightning. Underground cables, although apparently the solution to the problem, have not yet reached a high enough stage of development to be put into use.

The tests will be conducted under simulated operating conditions for a period of three years. This will permit testing of high-voltage instrumentation and dielectric characteristics on a larger, more practical scale than is usually possible.

(Ed. note: This testing program is just getting under way. The CORNELL ENGINEER will present an article in a later issue describing the testing in greater detail.)

TWO CORNELL PROFESSORS ATTEND ASCE CONVENTION

Two Cornell University professors, Gordon F. Fisher and William McGuire, both of the department of structural engineering, presented a paper entitled "Design and Construction in the Containment of Dynamic Loads," at the annual convention of the American Society of Civil Engineers, which was held in Washington, D.C.

The session was devoted to nuclear power construction. The paper discussed structural safety measures which have been taken to prevent danger from nuclear hazards and accidents at the Enrico Fermi nuclear power plant now under construction in Michigan. Both professors are consultants to Power Reactor Development Company, Inc. concerning structural safeguards against the danger of accidental nuclear explosion.

Professor George Winter, head of the department, presented a paper on "Cold-Formed, Light-gage Steel Structures," in which he reviewed the results of twenty years of research in this field carried out under his direction at Cornell.

ENGINEERS RECEIVE DRAVO CORPORATION AWARDS

A total of $10,500 in scholarships has been awarded to seven college students and their schools by Dravo Corporation, Pittsburgh, through the company's annual college and university program. Awards were made to two students each from the University of Pittsburgh, Cornell University, and Lehigh University. A student at Carnegie Institute of Technology also received an award.

Each scholarship consists of a $1000 grant for tuition and books as well as $500 for the individual college's general fund. If the student meets standards established

C. Hadley Smith

Associate Professor Joseph L. Rosson of the School of Electrical Engineering supervises the unloading of a high-voltage cable manufactured by the Okonite Company. It was the first 345,000 v underground cable to be manufactured in the United States. This cable, along with those submitted by other manufacturers, will be tested at the Cornell High-Voltage Laboratory.

by Dravo Corporation and his school, the $1500 grant is continued in his senior year. Since 1954, the program's first year, twenty-four students and their respective colleges have shared $63,000 in scholarship funds through the Dravo program.

A scholarship was granted to Cornell student Robert C. Waag, EE '61. Carl B. Loutzenhiser, CE '60 received a second-year grant.

Awards are based primarily on scholarship, leadership, and personal characteristics which indicate potential capacity to succeed. The grants are designed to help further the interests of outstanding students and to encourage them to choose industrial careers in engineering and business administration.

DEAN'S HONOR LIST 1958–59

School of Mechanical Engineering

Eugene Leonard Appel, Sherwood Brewster Bliss, Louis Lawrence Bucciarelli Jr., Justin Frank Camarata, Robert Codner Carlson, William LaMar Coggshall, George R. Cohen, William Varner Dietrich, Stephen Aaron Engelberg, Harry Alan Fertik, Frank Raymond Hammond, Edward Joel Ignall, Paul Kingston Johnson, Timothy Joseph Keliher, David Steven Kessler, Edward William Kobernusz, Leonard Stanley Lebow, Alan Lippert, Jack Dalton Loose, Paul Julian Mode Jr., Richard Douglas Nelson, Robert Christian Pfahl Jr., Carl Theodore Pfirrmann, Glenn Burr Rogers, Robert Shaw Jr., Gerald Robert Spielvogel, John Lee Spivack, John Arthur Swamson, Robert Scott Teich, Joseph Francis Thomas, Igor Vargagolovcsenko, Robert Vernon Wagoner Jr., Julius Frederick Weinhold Jr., Royce Sheldon Williams, Robert Kenneth Wood, Philip Mayo Young.

Department of Engineering Physics

A. Lee Atkinson, Charles Allen Brau, David Storer Burnett, James Marl Davidson, Martin Feinroth, William Albert Friedman, Peter M. Goldreich, Kenneth Merrill Hanson, Alan Lowell Hoffman, John S. Ingley, Ronald Harry Kohl, Michael George Hauser, Edward Powell Loane, Ben Edward Lynch, Francis Landis Markley Jr., Peter H. Mengert, Park S. Nobel, Douglas Arthur Pinnow, Ronald Poggi, George Florent Reiter, Gerald Schubert, James C. Shelton III, Donald M. Spero, Joseph F. Terdiman, Arthur V. Trifari, Robert E. L. Turner, Saul Wasserman, Robert W. Weinman, Richard Alan Wolf, Philip Robert Yarnell.

The following names were omitted in the listing of the Dean's List for the School of Electrical Engineering last month: James R. Tallman, Ernest W. von Borstel.

NEW FORMULA TO SAVE MONEY ON ROCKET FAILURES

A simple method has been devised at Cornell University for rocket engineers to predict accurately how liquid fuel used as a coolant in modern, high-thrust rocket nozzles will be distributed during take-off. The technique promises to save United States taxpayers countless millions of dollars by eliminating rocket failures due to rocket nozzle burnout, according to Assistant Professor Howard N. McManus, who developed the method.

Professor McManus, a specialist in thermodynamics engineering, said the "cut and try process," which is expensive and slow, is being used at the present time in rockets that have film cooling systems. This system permits fuel to enter by tiny openings and to run along the inside wall of the rocket nozzles. The amount of fuel fed to the inner surfaces of the nozzles depends on the size of the apertures through which the fuel enters.

The work done at Cornell will allow rocket engineers to use a simple equation to determine how the liquid will distribute itself inside the nozzles in a new rocket design.

The nozzle wall temperature must be kept at a much lower temperature than that of the rocket gas at the point of evaporation. Failure to cool a rocket nozzle adequately results in its disintegration. The rocket may be driven off course during the first three critical minutes of takeoff because of unequal thrust. The rocket must then be exploded in mid-air at a cost as high as two million dollars.

As a result of the Cornell engineer's work, the department of thermal engineering in the Sibley School of Mechanical Engineering has just been granted an additional $35,700 for a three-year period by the National Science Foundation. The grant will be used partly to compile additional data concerned with rocket nozzles and the rest will be spent on research concerning the results of roughness inside a tube or pipe on heat transfer and pressure drop.

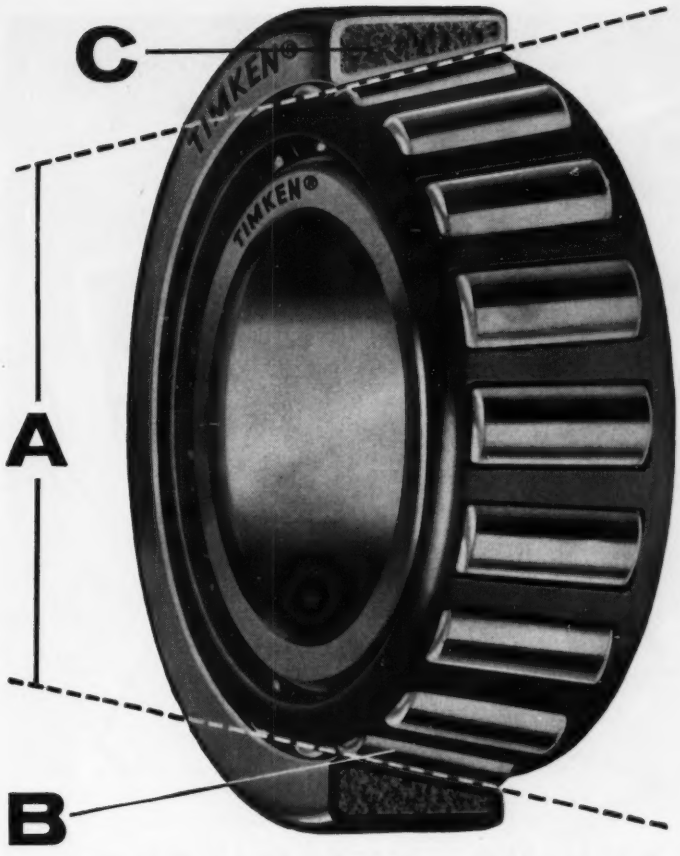
Before coming to Cornell in 1957, Professor McManus was an assistant professor of mechanical engineering at Northwestern University. He earned his B.S. degree in mechanical engineering in 1951 from the University of Iowa, and the M.S. and Ph.D. degrees in 1952 and 1956 from the University of Minnesota.

E.E. SCHOOL OFFERS COURSES FOR TELEPHONE ENGINEERS

A special two-part program headed by Professor Howard G. Smith of the School of Electrical Engineering is bringing the training of New York Telephone Company engineers up to date. The first half of the five-year program will be completed this month. By that time, each of 240 participating engineers will have studied here nine weeks. Their studies are designed to help them cope with the applications of the latest developments in electronics to the telephone industry.

The second part, to begin in January, will consist of abridgements of twelve standard fourth-year, fifth-year, and graduate electrical engineering courses. About half of those who participated in the first part will participate in the second. Each engineer will study here for eight 3-week periods during the next two and a half years.

Professor Smith is coordinator of the program. Charles E. Waldner, E.E. '23, who is general staff engineer for New York Telephone, serves as liaison between the University and the company. The first part was taught by five permanent faculty members and four retired Bell System men who joined the faculty as visiting lecturers. The second part will be taught entirely by permanent faculty members.



What is a Timken® tapered roller bearing?

IT'S an anti-friction bearing that's geometrically designed to give true rolling motion—and precision-made to live up to that design. Here's how you, as an engineer, can benefit from Timken® bearings:

A. *Tapered design* enables a Timken roller bearing to take any combination of both radial and thrust loads. You'll often find that one Timken bearing does the load-carrying job of two ball or straight roller bearings.

B. *Full line contact* between rollers and races gives Timken bearings *extra* load-carrying capacity. This enables a design engineer to cram maximum capacity into minimum space. And Timken bearings can be pre-loaded for accurate gear or spindle alignment.

C. *Case carburization* makes the steel of Timken bearing races and rollers hard on the outside to resist wear, tough on the inside to resist shock. This prolongs the life of Timken bearings. And the steel we start with is the best. It's nickel-rich for toughness.

What is Better-ness? It's our word for the result of the ceaseless American urge to make machines that do more, do better, do faster. Our engineers help make Better-ness possible. They've pioneered every major tapered roller bearing advance. And they work right at the drawing board with engineers of every major industry. It's exciting, rewarding work with a future.

If you would like to help create Better-ness on our engineering team, write Manager, College Relations, The Timken Roller Bearing Company, Canton 6, Ohio.

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Electronics	Thermodynamics
Metallurgy	Astrophysics
Vibration	Aerodynamics
Mechanics	Thermoelectricity

. . . are being brought to bear on a varied list of new products such as:

MinIRcooler — A tiny (10 ounce) device for cooling infrared detection equipment to minus 350°F. The coolers have endless applications in missile guidance, mapping, surveillance by orbiting satellites, etc.

SOLAR CELL — A small concave dish-like device with a highly polished surface used to convert the energy of the sun's rays into electrical energy. One potential use is power generation for earth satellites.

Other recently designed and developed products are:

ANTI-LUNG which reverses the cycle of the human lung to reconstruct the atmosphere in a space vehicle or submarine

A REFRIGERATOR with no moving parts

A TOOL that slices diamonds like cheese

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Manufacturers of: Engine Controls Hydraulic Equipment Electronic Controls and Instrument Systems
Starters Propellers Environmental Conditioning Systems Ground Support Equipment

FIFTY YEARS AGO IN THE ENGINEER

Monsieur Blériot, who crossed the English Channel with his aeroplane, gives some curious facts concerning the atmospheric vagaries that aviators are liable to encounter. Especially in the neighborhood of hills or mountains sudden eddies are apt to form in the air, even when there is little wind, and these, although unnoticeable from the ground, form a source of danger to the aviator. Sometimes the machine is whirled rapidly round, and the rider loses control of its direction; sometimes the sudden change of pressure brings a dangerous strain upon the apparatus. Monsieur Blériot has been involved in eddies which brought to bear a pressure which seemed to chain him fast in his seat, only to be followed by a sudden release which caused the aeroplane to bound as if hurled from a springboard. Instructed by these experiences, he is now turning his attention to modifying his apparatus to meet the unexpected atmospheric conditions. *The Sibley Journal*—December, 1909.

In surveying the scientific achievements of the past year, the greatest strides perhaps, have been made in the fields of aerial navigation. The year 1908 was one of experiments while 1909 has been the year of many brilliant achievements. The magnificent experiments of Curtis and the Wright brothers excited the admiration of all and the nation has been well represented at all times by them. Within the past twelve months, the definite conquest of the air has been accomplished, dirigible balloons have cruised about in the atmosphere and returned without difficulty to the starting points; aerial voyages have been made in machines "heavier than air."

. . . In another part of this Journal, notice is given that a new course, Aerial Engineering, will be given in Sibley College next year. Judging from the interest and enthusiasm shown in the Aero Club during the past few months, this course will prove to be a very popular one with the undergraduate body. By the establishment of this course, Cornell maintains her high standing as a technical school; few other universities or colleges offering such a course at the present time. The fundamental principles of aviation include a thorough and complete knowledge of physics, mechanics, aerodynamics, and the higher mathematics. Aerial navigation in itself is dangerous, unless these underlying principles are understood and the technical school is the place to learn them. A certain amount of practical knowledge is also required but this can be easily acquired knowing the theory. This field has an extremely bright future and the technical graduates who can combine their theoretical learning with the modern practical knowledge have good chances for advancement. *The Sibley Journal*—December, 1909.

Merely to make a living or to live for the pleasure of physiological functions, is not life; these do not give satisfaction. After many other formulas of life have failed, one finds that the only formula that truly satisfies is: to live for the realization of high ideals. This does not mean that such ideals will be fully realized in one's life; on the contrary, realized ideals become hindrances to further development, if considered as final goals. To live for ideal tendencies is a better definition of the purpose of life. *The Sibley Journal*—October, 1909.

. . . Speaking of public health and college improvements, there is one more subject brought to mind—proper ventilation. The cause of bad ventilation in the rooms lies largely with the student body, who will often close all the windows in the recitation and draughting rooms. Go into the library reading room, and most likely you'll find all the windows tightly shut. With the coming of winter, the storm windows will soon appear, and the chance of a stray wisp of fresh air will be largely eliminated. So for the sake of good ventilation open the little holes in the outer windows part way, or at any rate open them when leaving the room. Then the next class will at least start with fresh air. If the professors and students would do this, there would be fewer headaches and fewer students falling asleep during lectures. —*The Civil Engineer*, December, 1909.

Our college has outgrown its home in Lincoln Hall. Today a number of regular C.E. subjects are given in Goldwin Smith and in Franklin Hall. Moreover the freshmen classes are always increasing in size, 1913 numbering near two hundred. For some time we have longed for the extension to the building which is provided for in the general scheme of the campus. This the trustees have not seen proper to give us; but now we come to them with a less expensive proposition which will temporarily relieve the pressure—an additional story to Lincoln.

. . . It simply means the carrying up of the outer walls, and without increasing the height of the building, the eliminating of the present attic. The whole top of the building would thus be turned into a well lighted draughting room, something sorely needed. The lower two floors will be divided into recitation rooms. *The Civil Engineer*—December, 1909.

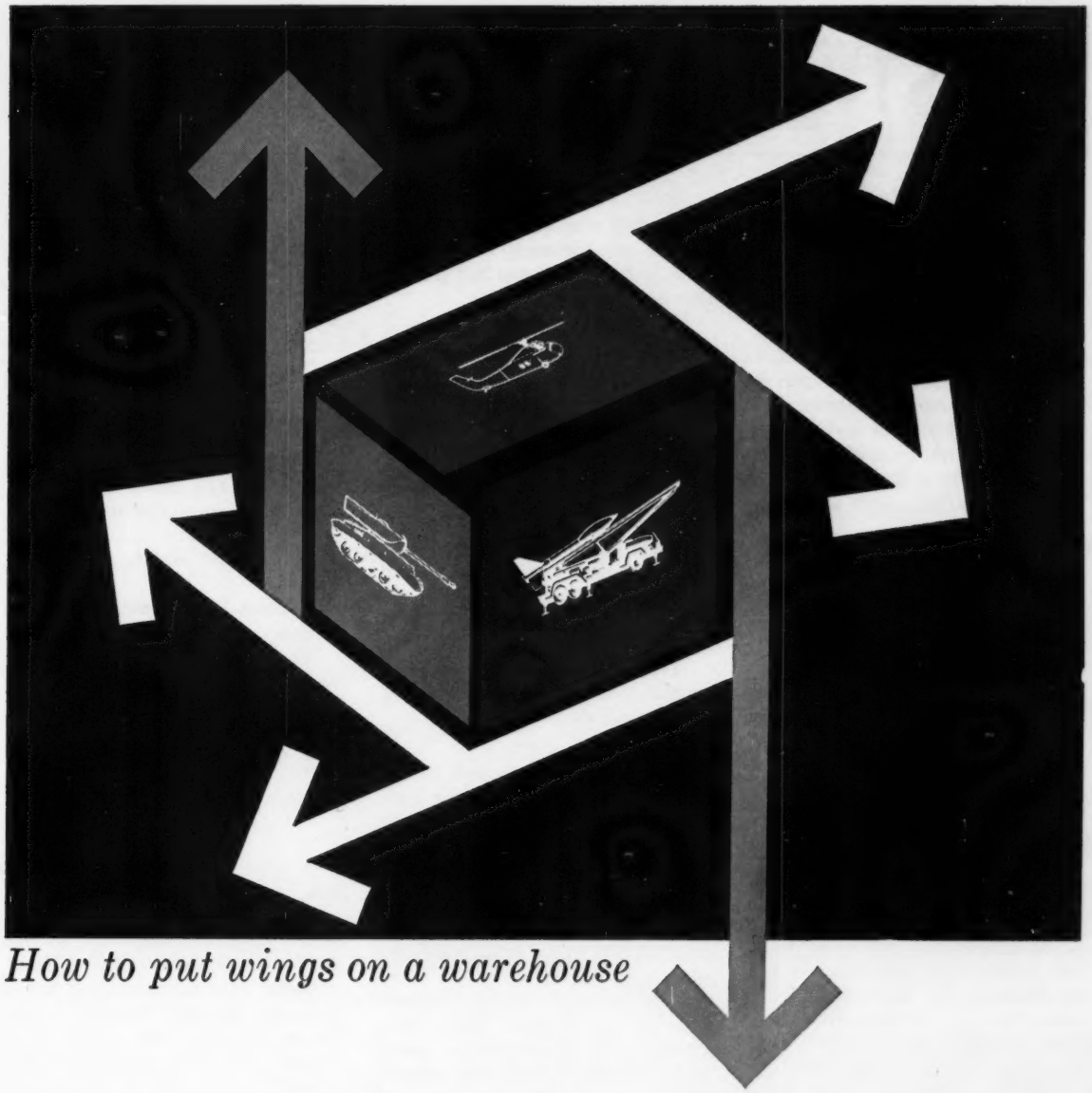
Most cities throughout the country spend thousands of dollars on quick acting fire alarm systems, quick hitching apparatus, well trained fire horses, and similar provisions for getting the fire department as quickly as possible to the scene of the fire. At the same time, they neglect to train their fire departments in the best technical methods for handling all classes of fires, and bungling rule-of-thumb methods are employed by fire chiefs throughout the country.

To develop the highest ability and skill in the commanding officers, it is essential that they should be thoroughly grounded in the fundamental scientific and technical elements of their profession. Unfortunately, the chiefs of fire departments are not given opportunities to obtain this broad training as a foundation for their skill, even though fully efficient fire fighting calls for engineering skill of the highest order; skill based on a thorough understanding of the many technical principles involved. The modern fire chief should be an authority on hydraulics, on mechanical engineering, on electricity, on combustion and explosives and numerous other branches of scientific knowledge, and should as well be so trained as to be able instantly to grasp the best lines of attack on any fire. *The Sibley Journal*—December, 1909.

One of the signs of spring is always the excitement and talk about camp. Even now all the officers are elected and the parties made up. Unless this class is an exception, they have to look forward to one of the best times of the whole college course. When ninety or one hundred fellows get together there is sure to be something doing all the time. There is plenty of hard work to do and many discomforts, but one soon gets dried out from a rain, a strong wind means the excitement of holding down the mess-tent, and cold weather is only a good excuse for more bon-fires.

The men who are not going to camp may say, "I feel sorry for you having to go out to camp and work, while we are playing around," but they do not know anything about it. Ask the Seniors who have been out there; they will give you a different view on the subject. Whenever a bunch of Seniors get together, camp is always one of the subjects most talked about. If a fellow does not get into the life and enjoy it, it is his own fault.

An entertainment for the farmers of the neighborhood is always a good thing for all concerned. It is very little trouble to get up and it creates a very friendly feeling among the farmers. Something should be done in return for tramping over their fields and scaring their stock. From our entirely selfish stand-point, we are sure it meant more cider and pies for lunch for those on their plots. Wherever the camp is this year, even without a swimming hole, it is a thing to look forward to with pleasure. *Cornell Civil Engineer*—April, 1908



How to put wings on a warehouse

Giving overseas air bases what amounts to local warehouse service on important parts is an Air Force objective. Its present system has slashed delivery schedules up to *20 times*...saved taxpayers several *billion* dollars over the past decade. To improve it further, Douglas has been selected to develop specifications for a comprehensive Material Handling Support System involving better communications, control, cargo handling and loading, packaging and air terminal design. Douglas is well qualified for this program by its more than 20 years in all phases of cargo transport. Air logistics is only one area of extensive Douglas operations in aircraft, missile and space fields in which outstanding openings exist for qualified scientists and engineers. Write to C. C. LaVene, Box B-600, Douglas Aircraft Company, Santa Monica, California.

Schuyler Kleinhans and Charles Glasgow, Chief Engineers of the Santa Monica and Long Beach Divisions, go over air transport needs relating to advanced cargo loading techniques with Donald W. Douglas, Jr., President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

STRESS *and* STRAIN . . .

The early bird gets the worm, but did you ever consider what the early worm gets?

• • •

Through the smoke and ozone fumes, the student slowly rises;
His hair is singed, his face is black, his partner he despises;
He shakes his head and says to him, with words so softly spoken,
"The last thing that you said to me was, 'Sure, the switch is open!'"

• • •

A hen, hit by an army jeep, got up, straightened out her feathers and said, "Lively little cuss, . . . but he didn't get anywhere."

• • •

The over-cautious old lady had pulled to a stop at the intersection. Three times the light changed green-yellow-red. Still she peered anxiously in all directions. Finally an officer pulled up alongside and asked. "What's the matter, lady, ain't we got any colors you like?"

• • •

Girls are like newspapers. They all have form; they always have the last word; back members are not in demand; they have great influence. You can't believe everything they say; they are getting thinner than they used to be; they get along by advertising; and every man should have his own and not try to borrow his neighbor's.

• • •

Little Boy in Woodshed: "Father, did grandpa spank you when you were a little boy?"
Father: "Yes."
Little Boy: "And did great-grandpa spank grandpa when he was a little boy?"
Father: "Yes."
Boy: "Well, don't you think with my help you could overcome this inherited sadism?"

• • •

Book Salesman: "Young man, you need this book. It will do half your college work for you."
M.E.: "Fine, give me two."

The best way to get ahead is to be like a swimming duck. Keep calm and cool on top but paddle like hell underneath.

• • •

A young druggist was left in charge of the store while the owner went for a cup of coffee. When he returned he inquired how the young man had made out.
"Oh, just dandy—I cured a lady's cough."
"What did you give her?"
"Well, I gave her a malted milk with four ounces of mineral oil and five ounces of castor oil in it."
"My God, that won't cure a cough!"
"Yeah? Just look at who's leaning on that lamppost across the street. She doesn't *dare* cough!"

• • •

We were given two ends to use. One to think with; one to sit with. Success depends on which we use. Heads we win; tails we lose.

• • •

A fugitive scientist from a Boris Karloff horror picture dreamed up a serum that would bring inanimate objects to life. He surreptitiously tried it out on the statue of a great general in Central Park. Sure enough, the statue gave a quiver and a moment later the general, creaking a bit in the joints, climbed down from the pedestal. The scientist was overjoyed. "I have given you life," he exalted, "Now tell me General, what is the first thing you are going to do with it?"
"Tha's easy," rasped the General, ripping a gun from his holster. "I'm going to shoot about two million damn pigeons."

• • •

Anyone who thinks he's indispensable should stick his finger in a bowl of water and notice the hole it makes when he pulls it out.

• • •

The old engineer pulled his favorite steam engine up to the water tank and briefed the new fireman. The fireman got up on the tender and brought the spout down all right, but somehow his foot caught in the chain and he stepped into the tank. As he floundered in the water, the engineer watched him with a jaundiced eye.
"Just fill the tank with water, Sonny," he said. "No need to stamp the stuff down."

• • •

A new ROTC officer approached the young man in the neatly fitting uniform and asked:
"What's the eighth general order?"
"I don't know," the fellow admitted.
"Have you ever been out for drill?"
"Nope."
"Don't you know enough to say 'sir,' either? What outfit are you in?"
"Me? I'm the Coca-Cola man."

• • •

A little boy about to show his pet rabbit to a guest was entering the drawing room with the animal when the rabbit proceeded to give birth to an enormous litter of baby rabbits. The boy watched for a moment, dropped the mother rabbit to the floor, and cried, "Holy Smoke, the damn thing is falling apart."

• • •

Counselor: "How do you like this room as a whole?"
Freshman: "As a hole it is fine; as a room, not so good."

• • •

Politician: "Congratulate me dear, I got the nomination."
Wife: Honestly?"
Politician: "Why bring that up?"

• • •

"Madam, may I see your daughter?"
"No. Get out and stay out."
"But, madam, see this badge? I'm a detective."
"Oh, I'm sorry; come in. I thought it was a fraternity pin."

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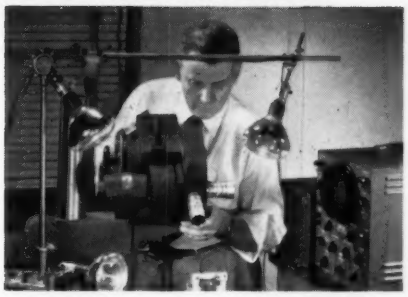

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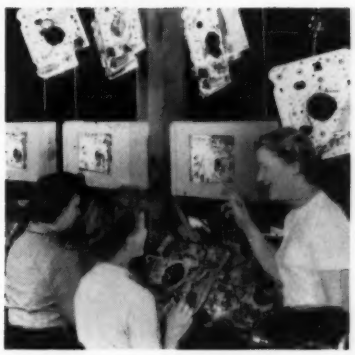

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Interview with General Electric's
Charles F. Savage
Consultant—Engineering Professional Relations

How Professional Societies Help Develop Young Engineers

Q. Mr. Savage, should young engineers join professional engineering societies?

A. By all means. Once engineers have graduated from college they are immediately "on the outside looking in," so to speak, of a new social circle to which they must earn their right to belong. Joining a professional or technical society represents a good entree.

Q. How do these societies help young engineers?

A. The members of these societies —mature, knowledgeable men— have an obligation to instruct those who follow after them. Engineers and scientists—as professional people—are custodians of a specialized body or fund of knowledge to which they have three definite responsibilities. The first is to *generate* new knowledge and add to this total fund. The second is to *utilize* this fund of knowledge in service to society. The third is to *teach* this knowledge to others, including young engineers.

Q. Specifically, what benefits accrue from belonging to these groups?

A. There are many. For the young engineer, affiliation serves the practical purpose of exposing his work to appraisal by other scientists and engineers. Most important, however, technical societies enable young engineers to learn of work crucial to their own. These organizations are a prime source of ideas — meeting colleagues and talking with them, reading reports, attending meetings and lectures. And, for the young engineer, recognition of his accomplishments by associates and organizations generally heads the list of his aspirations. He derives satisfaction from knowing that he has been identified in his field.

Q. What contribution is the young engineer expected to make as an active member of technical and professional societies?

A. First of all, he should become active in helping promote the objectives of a society by preparing and presenting timely, well-conceived technical papers. He should also become active in organizational administration. This is self-development at work, for such efforts can enhance the personal stature and reputation of the individual. And, I might add that professional development is a continuous process, starting prior to entering college and progressing beyond retirement. Professional aspirations may change but learning covers a person's entire life span. And, of course, there are dues to be paid. The amount is graduated in terms of professional stature gained and should always be considered as a personal investment in his future.

Q. How do you go about joining professional groups?

A. While still in school, join student chapters of societies right on campus. Once an engineer is out working in industry, he should contact local chapters of technical and professional societies, or find out about them from fellow engineers.

Q. Does General Electric encourage participation in technical and professional societies?

A. It certainly does. General Electric progress is built upon creative ideas and innovations. The Company goes to great lengths to establish a climate and incentive to yield these results. One way to get ideas is to encourage employees to join professional societies. Why? Because General Electric shares in recognition accorded any of its individual employees, as well as the common pool of knowledge that these engineers build up. It can't help but profit by encouraging such association, which sparks and stimulates contributions.

Right now, sizeable numbers of General Electric employees, at all levels in the Company, belong to engineering societies, hold responsible offices, serve on working committees and handle important assignments. Many are recognized for their outstanding contributions by honor and medal awards.

These general observations emphasize that General Electric does encourage participation. In indication of the importance of this view, the Company usually defrays a portion of the expense accrued by the men involved in supporting the activities of these various organizations. Remember, our goal is to see every man advance to the full limit of his capabilities. Encouraging him to join Professional Societies is one way to help him do so.

Mr. Savage has copies of the booklet "Your First 5 Years" published by the Engineers' Council for Professional Development which you may have for the asking. Simply write to Mr. C. F. Savage, Section 959-12, General Electric Co., Schenectady 5, N. Y.

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